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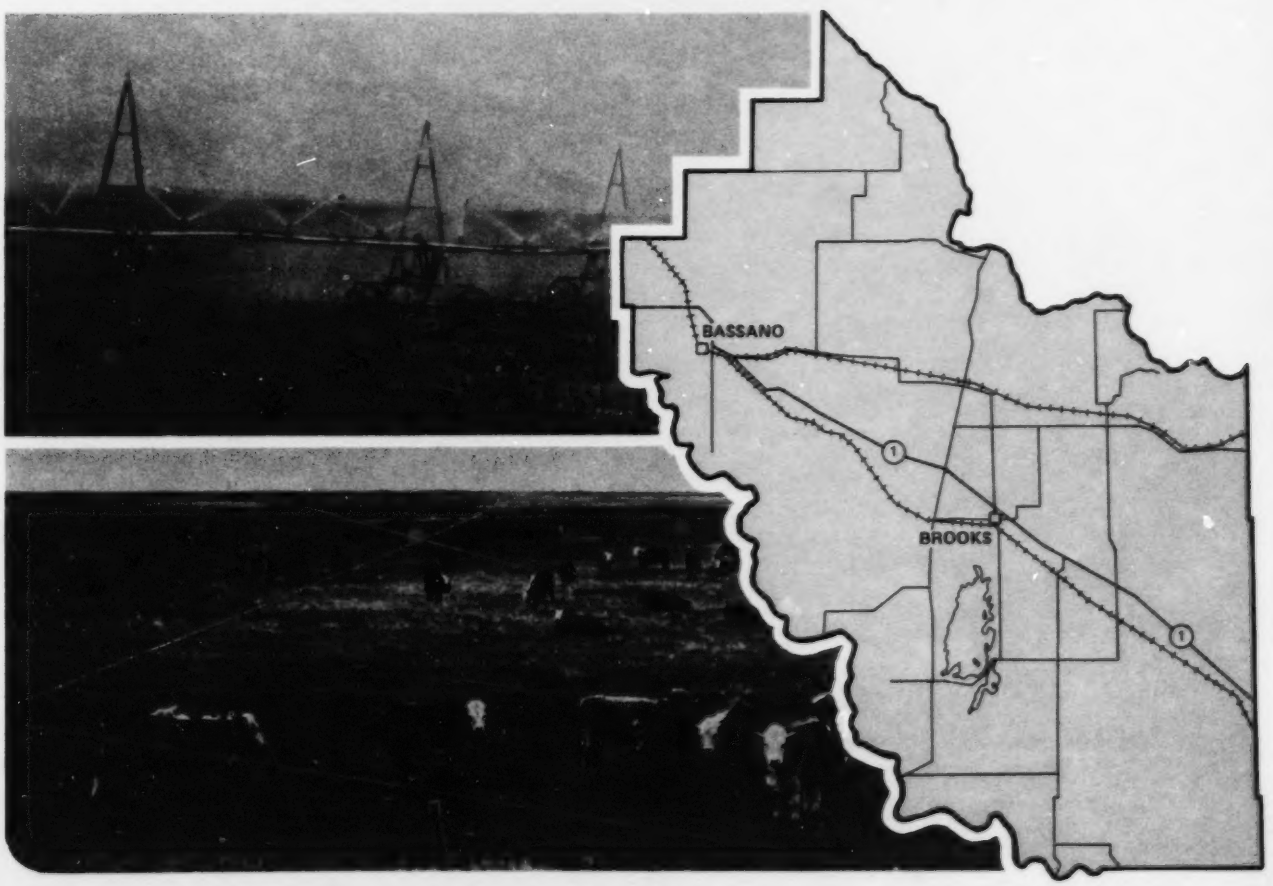
# Soil survey of the County of Newell, Alberta

## Report No. 41
## Alberta Soil Survey

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# Soil survey of the County of Newell, Alberta

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Alberta Soil Survey Report No.
Alberta Institute of Pedology Report No. S-82-41
Land Resource Research Institute Contribution No. LRRI 83-48

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Research Branch
Agriculture Canada
1983

Copies of this publication are available from
Agriculture Canada — Soil Survey
Terrace Plaza, Calgary Trail South
Edmonton, Alberta
T6H 5C3
or from
Faculty of Extension
University of Alberta
Edmonton, Alberta
T6G 2E1

Produced by Research Program Service

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Cat. No. A57-351/41-1983E ISBN: 0-662-12795-1

## SUMMARY

The County of Newell, in south-central Alberta, encompasses an area of more than 600 000 ha. It lies within the Alberta Plains physiographic region. Surface landform features are mainly those of an undulating till plain interrupted by areas of smoother topography indicative of water-laid deposits. Underlying soft rock formations of Upper Cretaceous age occur at relatively shallow depths, particularly on the eastern side of the county. Spectacular views of hoodoo formations on exposed soft rock materials can be seen along Red Deer River, especially in Dinosaur Provincial Park.

A continental type of climate prevails, with semiarid conditions, which results in native vegetative cover characteristic of the shortgrass prairie ecological region. Mean annual precipitation is about 335 mm, with two-thirds of that occurring during the growing season. The frost-free period is about 116 days.

Newell County lies almost entirely within the Brown soil zone. About half the soils are Chernozemic, a little more than one-third are Solonetzic, and the remaining soils belong to the Regosolic and Gleysolic orders. Approximately half of the land in the county is under cultivation and about one-third of the cultivated land is irrigated. Areas of native pasture are concentrated on the eastern side and in the northwestern portion of the county.



## RÉSUMÉ

Le comté de Newell, au centre-sud de l'Alberta, couvre une superficie de plus de 600 000 ha, qui s'étend dans la zone physiographique des plaines de l'Alberta. Les caractéristiques du modelé sont principalement celles d'une plaine de till onduleuse, interrompue par des zones de relief moins accidenté, formées par des dépôts alluvionnaires. Des roches tendres sous-jacentes, du Crétacé supérieur, se retrouvent à des profondeurs relativement faibles, en particulier dans la partie est du comté. Le spectacle splendide des <<cheminées de fées>> dans les formations de roche tendre exposée s'offre au regard le long de la rivière Red Deer, en particulier dans le parc provincial des Dinosauriens.

Il y règne un climat de type continental, avec des conditions semi-arides; la végétation indigène présente les caractéristiques de la région écologique des prairies à herbes courtes. La moyenne des précipitations annuelles est d'environ 335 mm, dont les deux tiers durant la période de végétation. La période sans gel est d'environ 116 jours.

Le comté de Newell se retrouve presque entièrement dans la zone des sols bruns. Près de la moitié des sols sont des sols chernozémiques, un peu plus du tiers, des sols solonetziques et le reste appartient aux ordres régosolique et gleysolique. Près de la moitié des terres sont cultivées, et parmi elles, près du tiers sont irriguées. Les zones de pâturages naturels sont concentrées dans les parties est et nord-ouest du comté.

# PREFACE

Soil surveys are an ongoing endeavor in Alberta, and have been since the early 1920's. As a result, almost all this province has been mapped at scales ranging from those used in a broad reconnaissance survey to those used in a very detailed soil survey. Although most of the settled portions of Alberta have been covered by a reconnaissance soil survey, many areas require resurvey and updating to current standards, particularly the areas covered by earlier surveys. In recent years resurveys have been conducted at the detailed reconnaissance scale, within boundaries of local administrative units, usually the county or municipal district.

This report of the soil survey of the County of Newell is at the detailed reconnaissance level. It covers part of several areas on which earlier soil surveys were conducted and for which reports were published, although some have long been out of print. The reports for the MacLeod sheet in 1925 (22), the Medicine Hat sheet in 1926 (23), and the Rainy Hills sheet in 1937 (24), which are out of print, cover the eastern part of the county. Later reports for the Blackfoot and Calgary sheets in 1942 (25), and the Rosebud and Banff sheets in 1943 (26), cover the western portion of the county.

The soils information that forms the basis for this report and accompanying soils maps was obtained during three stages of field work. The first occurred in the mid-1950's when the irrigated areas of the Eastern Irrigation District were surveyed to classify the soils and determine the extent of salinization. Two internal reports resulted from this work, covering the Tilley area (4) and the Patricia-Millicent area (10). The second stage, during the mid-1960's, resulted from the impetus generated by the Canada Land Inventory (CLI) program. During this time, survey coverage was limited to the eastern and southern parts of the county where information from soil surveys prior to 1940 was deemed inadequate for CLI purposes. From the CLI program, three reports on capability for agriculture were published, portions of which cover the county: the Medicine Hat sheet (16), the Gleichen sheet (11), and the Drumheller sheet (15). The final stage, during the latter part of the 1970's, was concentrated in the northwestern half of the county where dryland soils were mapped and classified. Also during this period, an extensive program of checking, correlation, and updating was conducted on the remainder of the county covered during the first two stages. Consequently, the present report combines the efforts of many individuals involved in soil survey during the periods mentioned.

## ACKNOWLEDGMENTS

The soil survey of the County of Newell was conducted by the Research Branch, Agriculture Canada, in cooperation with the Soils Division, Alberta Research Council and the Soils Department, University of Alberta.

The contributions of the following persons and organizations are hereby acknowledged, for their assistance in various ways during the course of this project.

- The late W.E. Bowser, former head of the Soil Survey Unit, for his direction during the earlier stages of this project.
- R. Ball, G. Benke, D. Bowser, A. Brunelle, J. deVries, B.I. Dickens, M.J. Dudas, L. Majeau, K. Mulak, P. Nielsen, W.L. Owen, N. Pitman, A. Quadri, and W. Romaniuk who assisted in the field during mapping and sampling.
- J. Beres, W.C. McKean, and A. Schwarzer who conducted the laboratory analyses.
- R.L. McNeil and J. Tajek who assisted in the preparation of manuscript maps and diagrams.
- Mrs. C. Lirette who typed the report manuscript.
- J.A. Shields, Western Correlator, Land Resource Research Institute, Ottawa, for his critical review of the manuscript and his helpful suggestions.
- D. Roll, Irrigation Specialist, Brooks, for his article on the Eastern Irrigation District.
- R.T. White, Manager of the Eastern Irrigation District, for information relative to the irrigation district.
- Cartographic Section, Land Resource Research Institute, Ottawa, for preparing the soils maps, the figures and the typography, for printing.
- Research Program Service for editing the manuscript and preparing the artwork for the cover.
- Alberta Research Council and University of Alberta who supplied office and laboratory space.
- Colleagues, including those of the Soils Division, Alberta Research Council, for their helpful suggestions, and their contribution to a congenial working environment.

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# PART I. PHYSICAL AND ENVIRONMENTAL FEATURES

## HISTORY AND DEVELOPMENT

The County of Newell No. 4, with an areal extent of 612 935 ha, lies in south-central Alberta between Calgary and Medicine Hat (Fig. 1). Early settlement, following the first railroad construction in 1883, developed into a great influx of homesteaders during the period 1909-1911. It soon became apparent to these early settlers that farming was a marginal operation under the limited rainfall conditions. Consequently, irrigation construction was initiated by the Canadian Pacific Railway; several years later the Eastern Irrigation District (EID) was formed to manage irrigation in the area, and the first irrigation water was delivered in 1914. All water for this irrigation district is diverted from Bow River by means of the Bassano Dam a few kilometres southwest of Bassano. The boundary of the EID is almost identical to that of the County of Newell except on the western side, where the county includes an additional area slightly in excess of two townships.

Major population centers are Brooks, with a population of about 6300, and Bassano, nearing 1000. Brooks, centrally located, is the main service center for both the agriculturally oriented economy and the widespread oil- and gas-related activities. A few kilometres east of Brooks, the Alberta Horticultural Research Centre provides research and extension services into specialty crops and ornamental and fruit trees.

The Trans-Canada Highway and Highway 36, which intersect west of Brooks, are the main highway routes through the county. From these highways feeder roads of good all-weather quality service the farming population, which is mainly concentrated in the irrigated areas. Water-based recreational facilities are available at Kinbrook Island Provincial Park on Lake Newell. A pheasant hatchery provided by the provincial government at Brooks releases pheasants into the surrounding countryside, providing game for the avid bird hunter. Of unique interest is Dinosaur Provincial Park on Red Deer River in the northeast corner of the county. Here one can view the skeletal remains of the mighty dinosaurs that roamed the area some 70 million years ago. This park also offers some of the most picturesque views of badland landscapes, hoodoo formations, and other erosional landforms (Fig. 2).

## CLIMATE

The County of Newell has a continental type of climate, characterized by warm summers and cold winters (Table 1), which is typical of the prairies. It is a semiarid region with a high annual moisture deficiency (Table 2). However, of great importance to agriculture, particularly dryland agriculture, is the fact that more than 60% of the total precipitation falls during the growing season, from May to September. For comparison, data from Alberta Environment (2) collected at other points in the province has been included in Table 1.

LEGEND

11 Blackfoot and Calgary sheets
12 Rosebud and Banff sheets
13 Wainwright and Vermilion sheets
14 Peace Hills sheet
15 Rycroft and Watino sheets
16 Red Deer sheet
17 High Prairie and McLennan sheets
18 Grande Prairie and Sturgeon Lake sheets
19 Rocky Mountain House sheet
20 Beaverlodge and Blueberry Mountain sheets
21 Edmonton sheet
22 St. Mary and Milk River project
23 Cherry Point and Hines Creek area
24 Buck Lake and Wabamun Lake area
25 Grimshaw and Notikewin area
26 Hotchkiss and Keg River area
27 Whitecourt and Barrhead area
28 Chip Lake area
29 Tawatinaw map sheet 83 I
30 Mount Watt and Fort Vermilion area
31 Hinton-Edson area 83F
31a North Saskatchewan River Valley
33 Waterton Lakes National Park
34 Sand River sheet
36 Oyen sheet
38 Elk Island National Park
39 Wapiti Map area
40 Brazeau Dam
41 County of Newell
M77-3 NW Lethbridge
M80-3 NE Lethbridge
58-1 Preliminary
59-1 Preliminary
60-1 Preliminary
61-1 Preliminary
62-1 Preliminary
63-1 Preliminary
64-1 Preliminary
64-2 Preliminary

Note: Reports published prior to 1942 are out of print but may be obtained on loan from the Alberta Soil Survey. These include: MacLeod sheet, Medicine Hat sheet, Sounding Creek sheet, Peace River, High Prairie, Sturgeon Lake area, Rainy Hills sheet, Sullivan Lake sheet, Lethbridge and Pincher Creek sheets, Milk River sheet, Rosebud and Banff sheets, and Wainwright and Vermilion sheets.

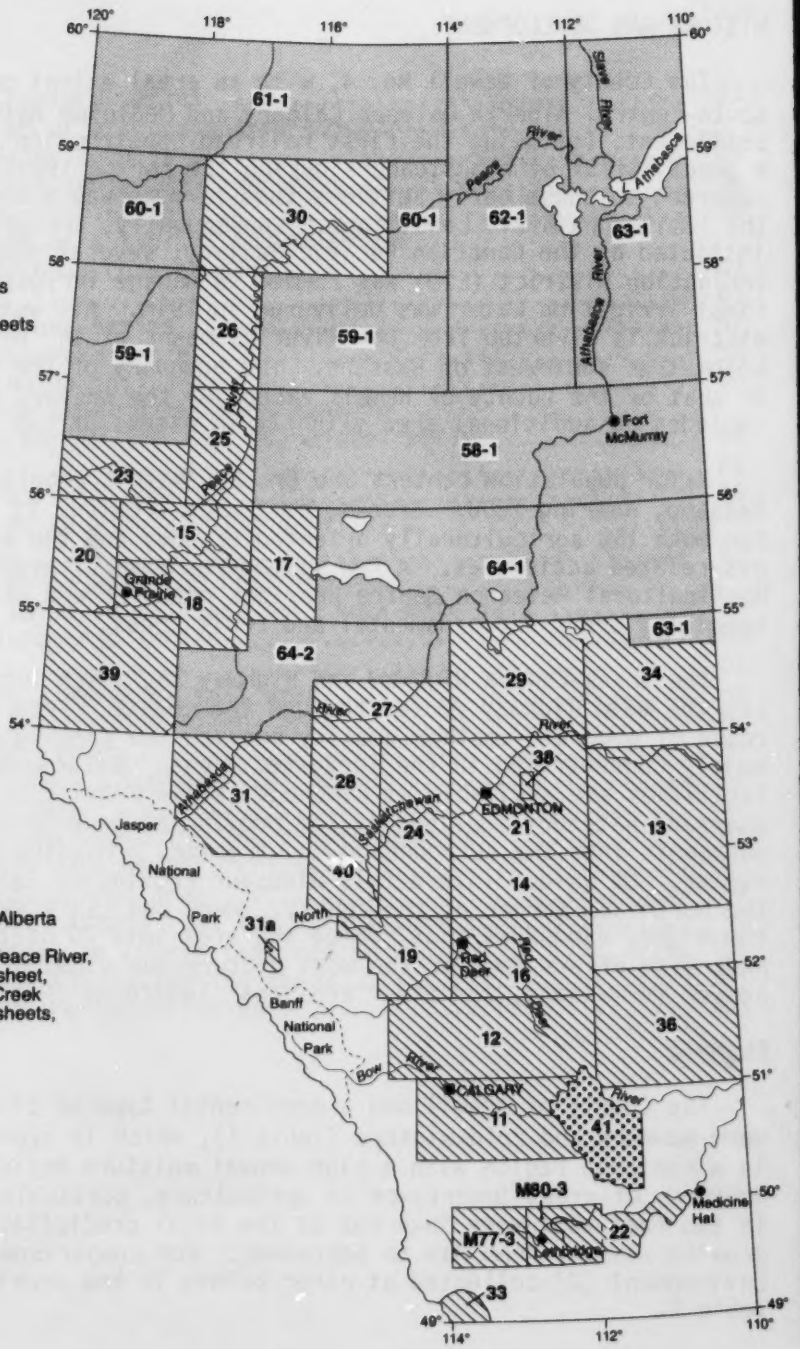



Figure 1. Location map of soil survey areas in Alberta.

Figure 2. Badlands of Dinosaur Provincial Park.

Table 1. Temperature and Precipitation at Selected Stations

| Station | Temperature (°C) | | | Precipitation | | |
|---|---|---|---|---|---|---|
| | July mean | January mean | Mean annual | May-Sept (mm) | Snow (cm) | Mean annual (mm) |
| Medicine Hat | 20.0 | -12.2 | 5.0 | 212 | 122 | 347 |
| Brooks | 18.9 | -12.8 | 3.9 | 224 | 106 | 355 |
| Lethbridge | 18.3 | -9.4 | 5.0 | 251 | 177 | 424 |
| Calgary | 16.7 | -11.1 | 3.3 | 301 | 154 | 437 |
| Edmonton | 16.1 | -16.1 | 1.7 | 321 | 131 | 459 |

Using climatic data from various meteorological stations, Chapman and Brown (7) have analyzed these figures and translated them into information meaningful to agricultural production (Table 2).

Table 2. Length of Growing Season, Frost-free Period, and Water Deficiency at Selected Stations

| | Med. Hat | Brooks | Lethbridge | Calgary | Edmonton |
|---|---|---|---|---|---|
| Length of growing season (days above 5.6°C mean temp.) | 190 | 183 | 186 | 172 | 168 |
| Frost-free period | 120 | 116 | 110 | 100 | 100 (days) |
| Average annual water deficiency (mm) for medium textured soil | 254 | 227 | 152 | 76 | 102 |

Tables 1 and 2 indicate that the Brooks area has an adequate length of growing season and frost-free period for the crops normally grown on the prairies under dryland conditions. However, precipitation is a definite limiting factor to crop production.

Using climatic data similar to the above, Bowser (5) compiled an agroclimatic map of Alberta which divides the province into a number of areas based on the limitations imposed by climate on cultivated dryland agriculture. As shown in Fig. 3, most of the county lies in agroclimatic area 3A which means that moisture is a moderately severe limiting factor to crop growth and the frost-free period is greater than 100 days. Only a small portion on the western side of the county lies in agroclimatic area 2A. In this area moisture has been a limiting factor to crop production in about half the years, but the frost-free period has usually been sufficiently long for wheat to mature without frost damage. This agroclimatic line corresponds roughly to the long-established boundary between the Brown and Dark Brown soil zones.

Figure 3 also shows the county divided into two subregions based on the limitations of climate, primarily heat units, for irrigated crop production. This climatic dividing line roughly approximates the 110-day frost-free period line established by Chapman and Brown (7); the longer period is to the east. West of the line the degree-days above 5°C are generally less than 1400, while to the east they are more than 1400. The eastern part of the county, in subregion I, has only a few climatic limitations to the crops normally grown under irrigation in Alberta, while in subregion II the climate places a more severe limitation on the choice of irrigated crops.

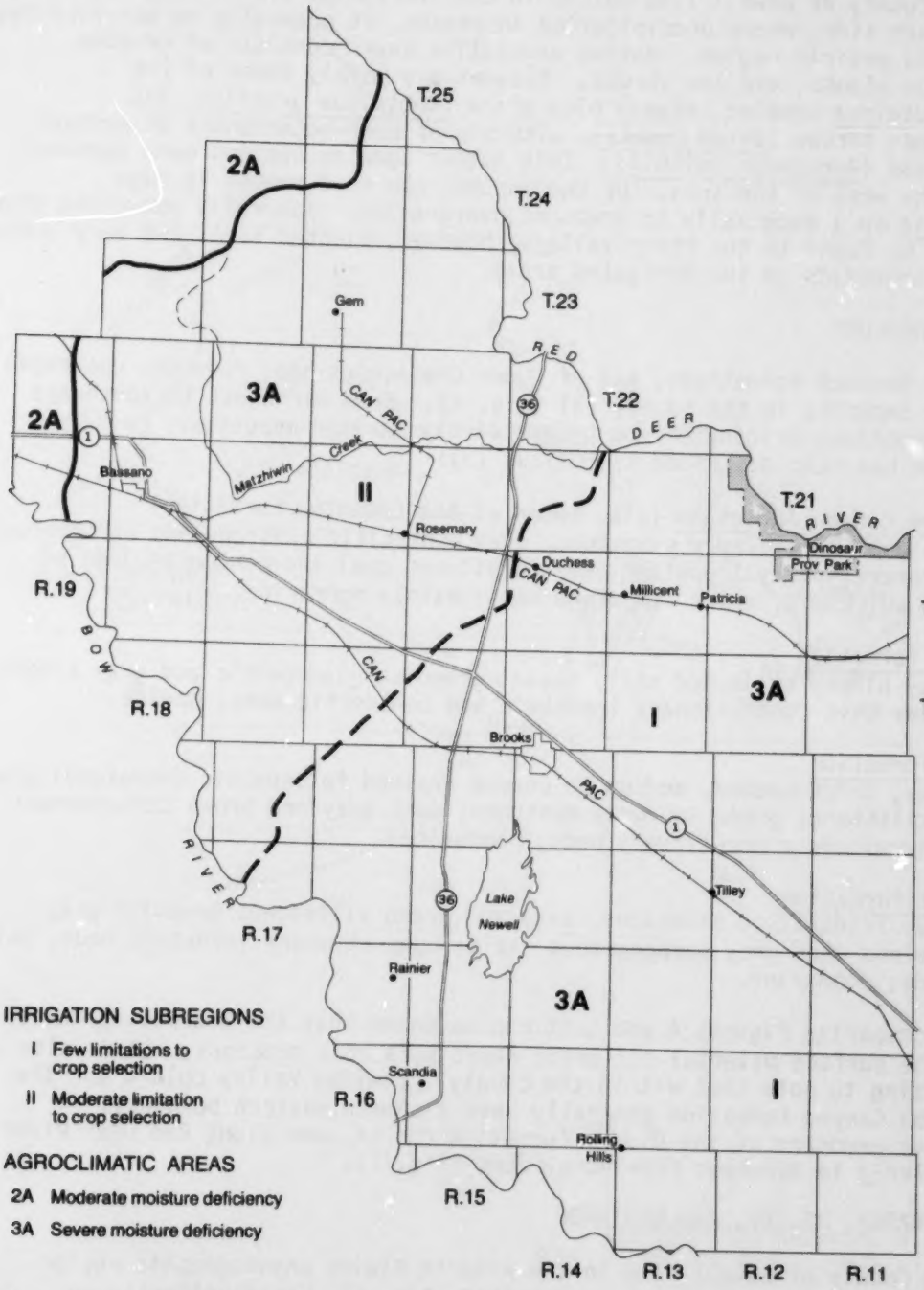



Figure 3. Agroclimatic areas and irrigation subregions in the County of Newell.

## VEGETATION

The County of Newell lies mainly in the shortgrass prairie region, but on the western side, where precipitation increases, it gradually merges into the mixedgrass prairie region. Native vegetative cover consists of grasses, herbaceous plants, and low shrubs. Grasses are mainly those of the Stipa-bouteloua complex, namely blue grama (Bouteloua gracilis) and needle-and- thread (Stipa comata), with significant occurrences of western wheat grass (Agropyron smithii). This latter species becomes more abundant toward the west of the area. Of the shrubs, the most common is sage (Artemisia sp.) especially in areas of overgrazing. Naturally occurring trees can only be found in the river valleys; however, planted trees are very common around farmsteads in the irrigated areas.

## BEDROCK GEOLOGY

Four bedrock formations, all of Upper Cretaceous age, form the uppermost geologic deposits in the county (3) (Fig. 4). From northwest to southeast these formations originate from progressively earlier deposits. Each formation has been described as follows (3):

Horseshoe Canyon formation (also known as the Edmonton formation)
Gray, feldspathic, clayey sandstone; gray bentonitic mudstone and carbonaceous shale; concretionary ironstone beds, scattered coal and bentonite beds of variable thickness, minor limestone beds; mainly nonmarine.

Bearpaw formation
Dark gray blocky shale and silty shale; greenish glauconitic and gray clayey sandstone; thin concretionary ironstone and bentonitic beds; marine.

Oldman formation
Pale gray, thick-bedded, medium to coarse grained feldspathic sandstone; gray clayey siltstone; green and gray mudstone; dark gray and brown carbonaceous shale; ironstone concretionary beds; nonmarine.

Foremost formation
Pale gray feldspathic sandstone; gray and green siltstone; greenish gray mudstone and dark gray carbonaceous shale; concretionary ironstone beds, thin coal beds; nonmarine.

In comparing Figures 4 and 5 it can be noted that the Bearpaw formation forms the surface material for areas where soft rock outcrops. It is also interesting to note that within the county, Crawling Valley Upland and the Horseshoe Canyon formation generally have a common eastern boundary. Extensive exposure of the Oldman formation can be seen along Red Deer River, particularly in Dinosaur Provincial Park (Fig. 2).

## PHYSIOGRAPHY, RELIEF, AND DRAINAGE

The County of Newell lies in the Alberta Plains physiographic region. Locally it can be divided into units (17) (Fig. 5), based primarily on elevations and major parent material distribution. On the western side, Crawling Valley Upland is characterized by its hummocky moraine (Fig. 6) and elevations generally ranging from 760 to 885 m above sea level. Crawling Valley, a glacial spillway with a valley depth of 25-30 m, is a distinct feature as it snakes its way through this upland area (Fig. 7).

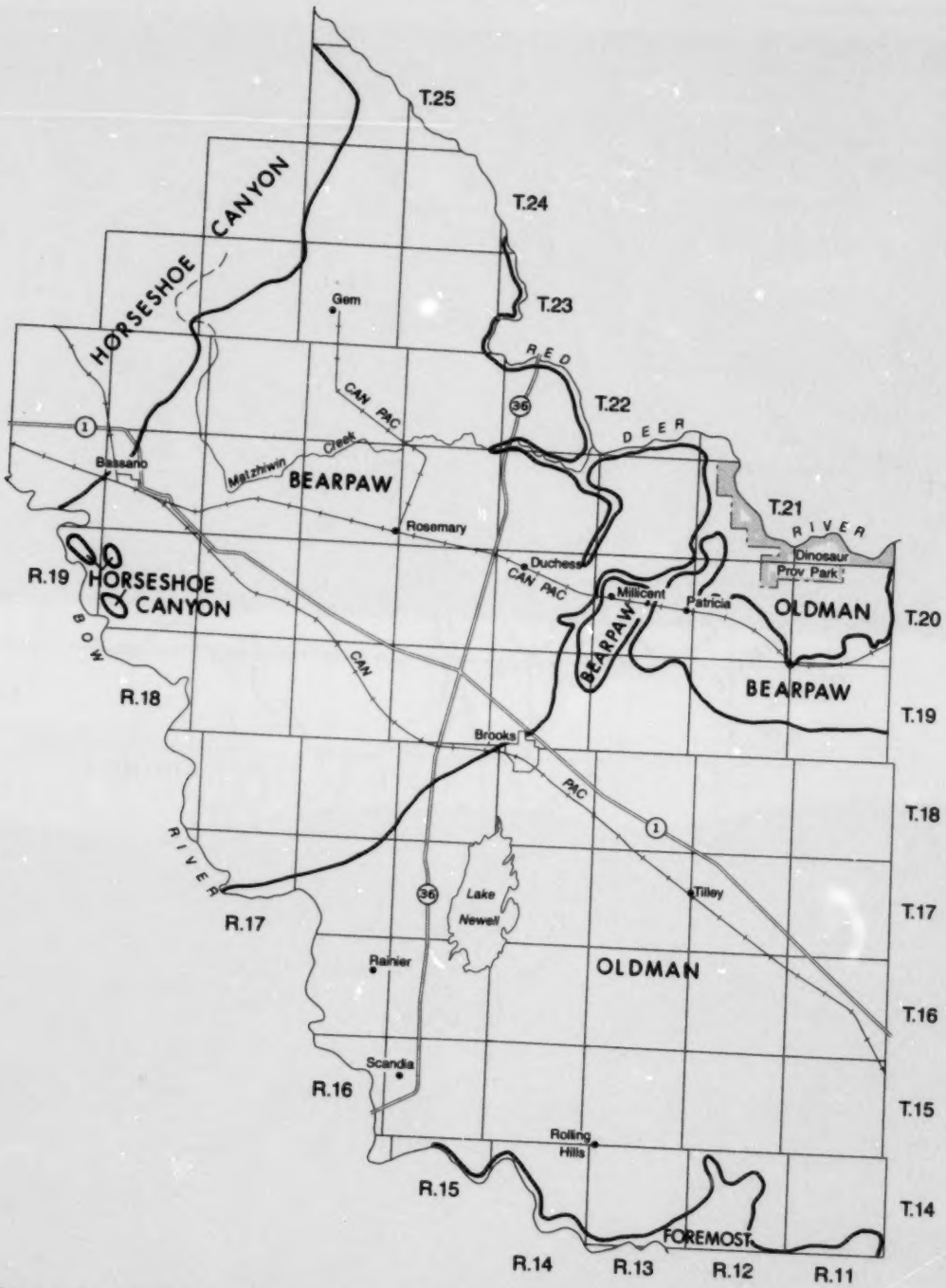



Figure 4. Bedrock formations underlying the County of Newell.

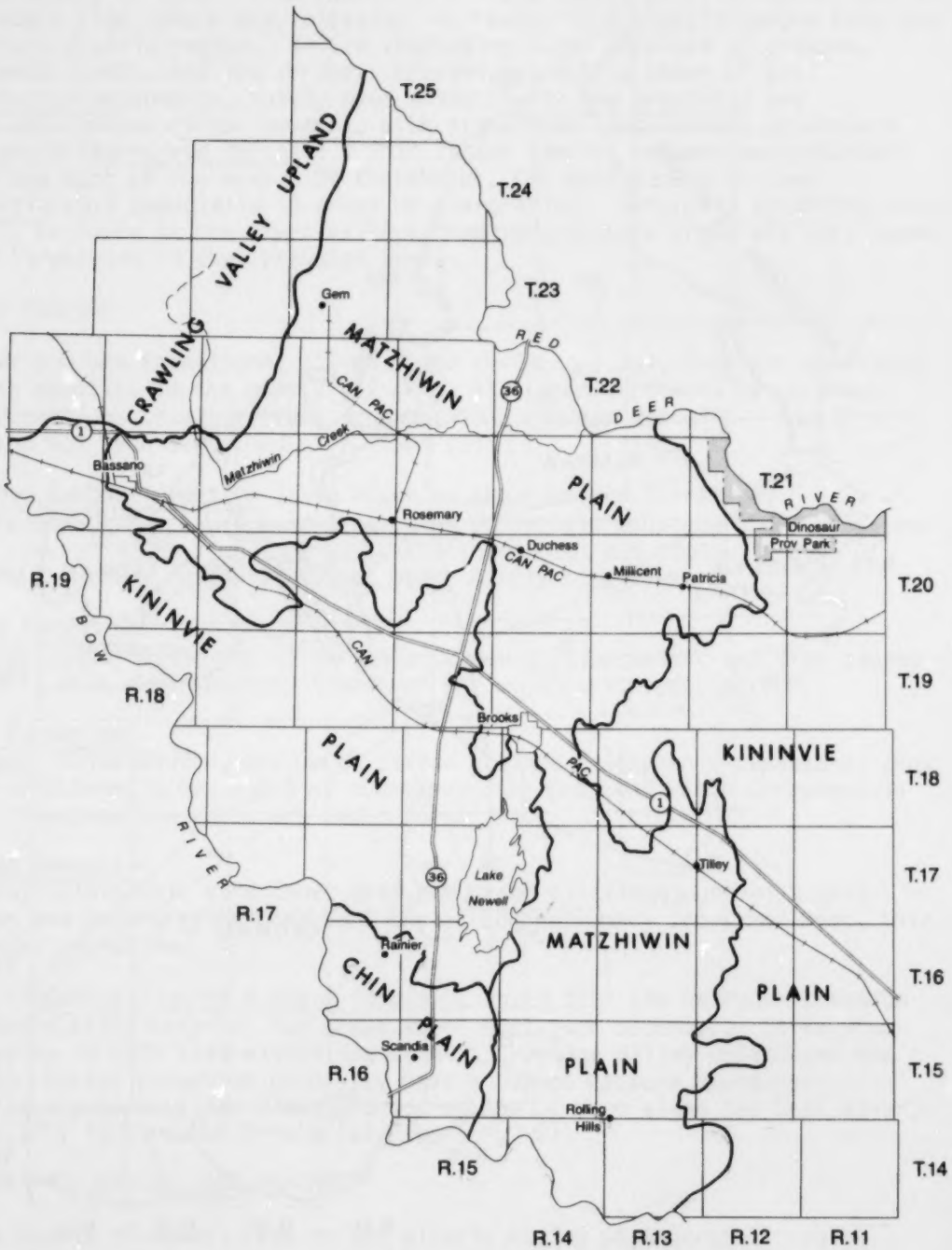



Figure 5. Physiographic districts of the County of Newell.

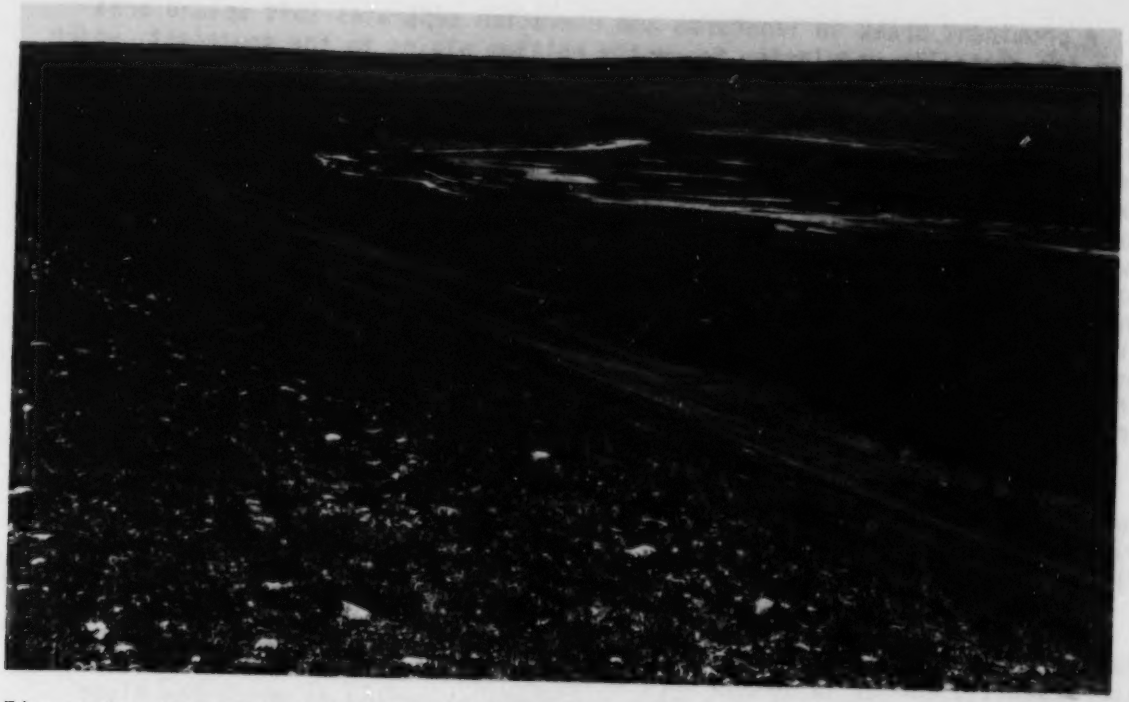


Figure 6. Hummocky moraine on Crawling Valley Upland.

Figure 7. Crawling Valley spillway.

A prominent break in landforms and elevation separates this upland area from the generally undulating to gently rolling plains to the southeast, which have been separated into smaller units on the basis of surface materials and elevation differences (Figure 5). Matzhiwin Plain is mainly composed of fluvial and lacustrine deposits. With elevations ranging from 700 to 760 m, this plain is generally lower than the remainder of the area and has the main concentration of irrigation. Kininvie Plain is separated into two parts by a southern extension of Matzhiwin Plain. The western portion of Kininvie Plain is primarily an undulating moraine with a few areas of higher relief and a few localized areas of soft rock outcrops. Elevations range from 760 to 790 m. The eastern portion is somewhat lower with elevations from 730 to 760 m. This plain is capped with either a blanket or a veneer of till, through which the underlying soft rock materials outcrop in several locations. A small portion of Chin Plain extends into this county along Bow River. It is mainly composed of fluvial and lacustrine deposits, and has an elevation of about 760 m.

Maximum elevation in the County of Newell is about 885 m in Crawling Valley Upland, where some of the roughest topography also occurs. The lowest elevation of the plains is about 725 m, in the northeastern part of Matzhiwin Plain.

The county is drained mainly by the Matzhiwin, Onetree, and Little Sandhill creeks, which all drain into Red Deer River. The lowest elevation, approximately 630 m, is on Red Deer River in Deadlodge Canyon within Dinosaur Provincial Park. This is about 20 m below the elevation at which Bow River flows out of the county, some 70 km to the south.

The areal extent and distribution of the various slope classes (or topography) that occur in the county are shown in Table 3, Fig. 8.

Table 3. Extent of Each Slope Class in the County of Newell

| Slope class | Slope range (%) | Area (ha) | Percentage of total area |
|---|---|---|---|
| 1 | 0 - 0.5 | 7 222 | 1.2 |
| 2 | 0.5 - 2 | 132 565 | 21.6 |
| 3 | 2 - 5 | 294 650 | 47.9 |
| 4 | 6 - 9 | 109 065 | 17.8 |
| 5 | 10 - 15 | 34 100 | 5.7 |
| 6 | 16 - 30 | 1 145 | 0.2 |
| RB | variably steep | 17 730 | 2.9 |
| $H_2O$ | | 16 470 | 2.7 |
| Total | | 612 935 | 100.0 |

Only a small proportion of the county has topography with undesirable steep slopes (Table 3). Furthermore, almost 3% of the area is covered by water bodies, which are mainly water storage reservoirs to ensure an adequate water supply during the irrigation season.

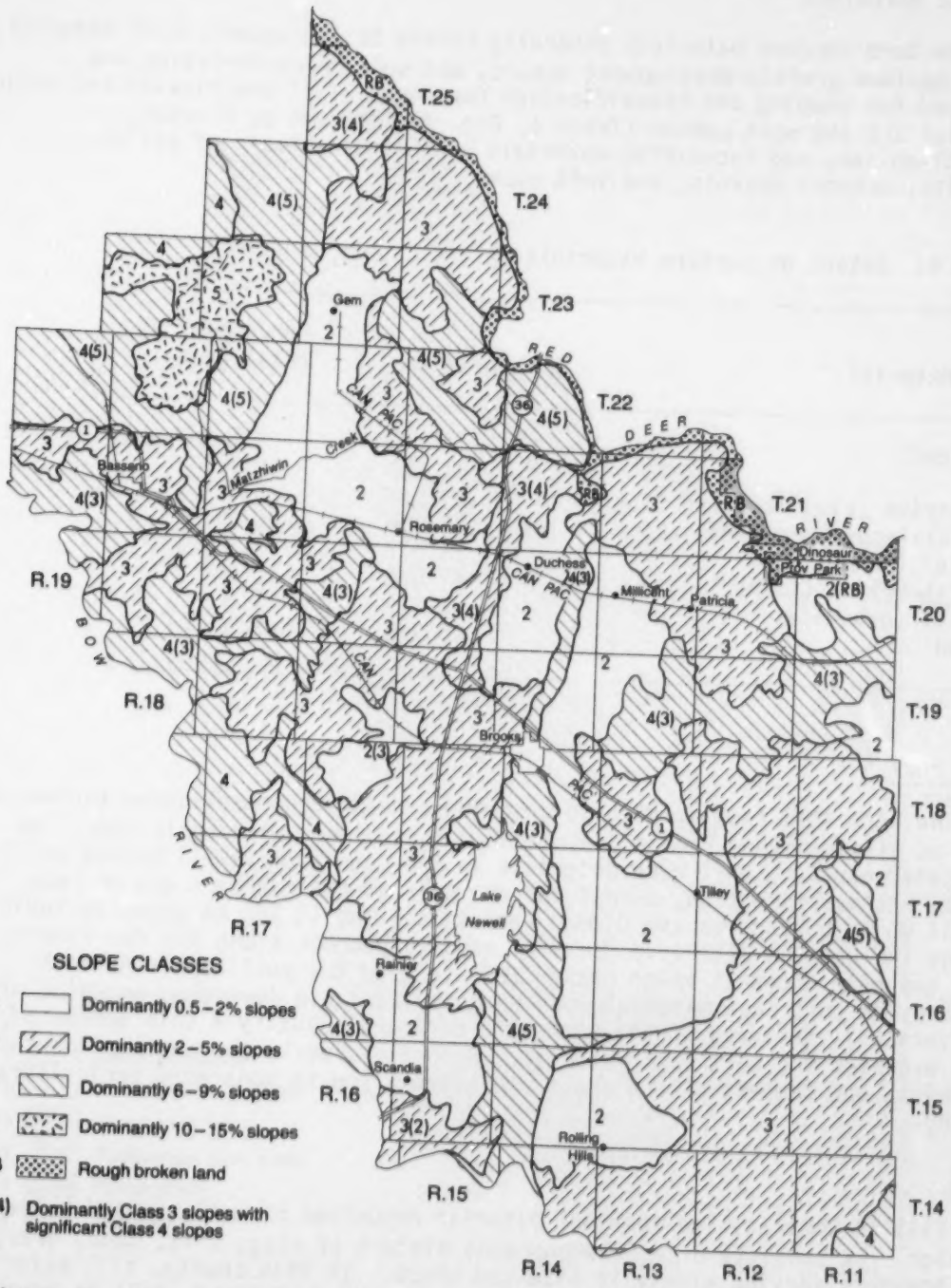



Figure 8. Generalized slope class map for the County of Newell.

## SURFACE MATERIALS

The term surface materials generally refers to the upper 1 m of material, where maximum profile development occurs, and soil characteristics are assessed for mapping and classification purposes. Till and fluvial-lacustrine material are the most common (Table 4, Fig. 9) followed by fluvial, fluvial-eolian, and lacustrine materials with minor amounts of eolian deposits, outwash gravels, and soft rock.

Table 4. Extent of Surface Materials in the County of Newell

| Material | Area (ha) | Percentage of total area |
|---|---|---|
| Soft rock | 12 180 | 2.0 |
| Till | 241 530 | 39.7 |
| Lacustrine (clay loam and finer) | 37 235 | 6.1 |
| Fluvial-lacustrine (loam and silt loam) | 124 550 | 20.3 |
| Fluvial (sandy loam) | 71 515 | 11.7 |
| Fluvial-eolian (loamy sand) | 61 595 | 10.0 |
| Fluvial (gravels) | 8 325 | 1.3 |
| Eolian | 10 350 | 3.3 |

### Soft rock

The term soft rock is used to describe a weakly unconsolidated sedimentary rock as distinguished from a consolidated igneous or metamorphic rock. As indicated earlier, soft rock materials in the County of Newell belong mainly to the Bearpaw formation, except for the area at the northern end of Lake Newell which belongs to the Oldman formation. The 12 180 ha shown in Table 4 do not include the extensive areas of exposed bedrock along the two rivers; that has been shown as rough broken (RB) land on the soil maps. Surface textures on soft rock materials can be quite variable depending on which of the variously textured strata forms the surface. Usually a thin veneer of till overlies the soft rock material. Solonetzic soils are dominant on this material, and therefore such areas are given a low to nonarable agricultural rating.

### Till

Till is unstratified morainal material deposited directly by and below a glacier. It consists of a heterogeneous mixture of clay, silt, sand, gravel, and boulders varying widely in size and shape. In this county, till materials generally have a clay loam texture. As indicated in Table 4, till is more widespread than any other material. Major areas of till (Figure 9) occur in Crawling Valley Upland, and from there southeastward along Bow River to Lake Newell. Another major area lies on the eastern side of the county. Soils of the Chernozemic and Solonetzic orders are predominant in the till areas.

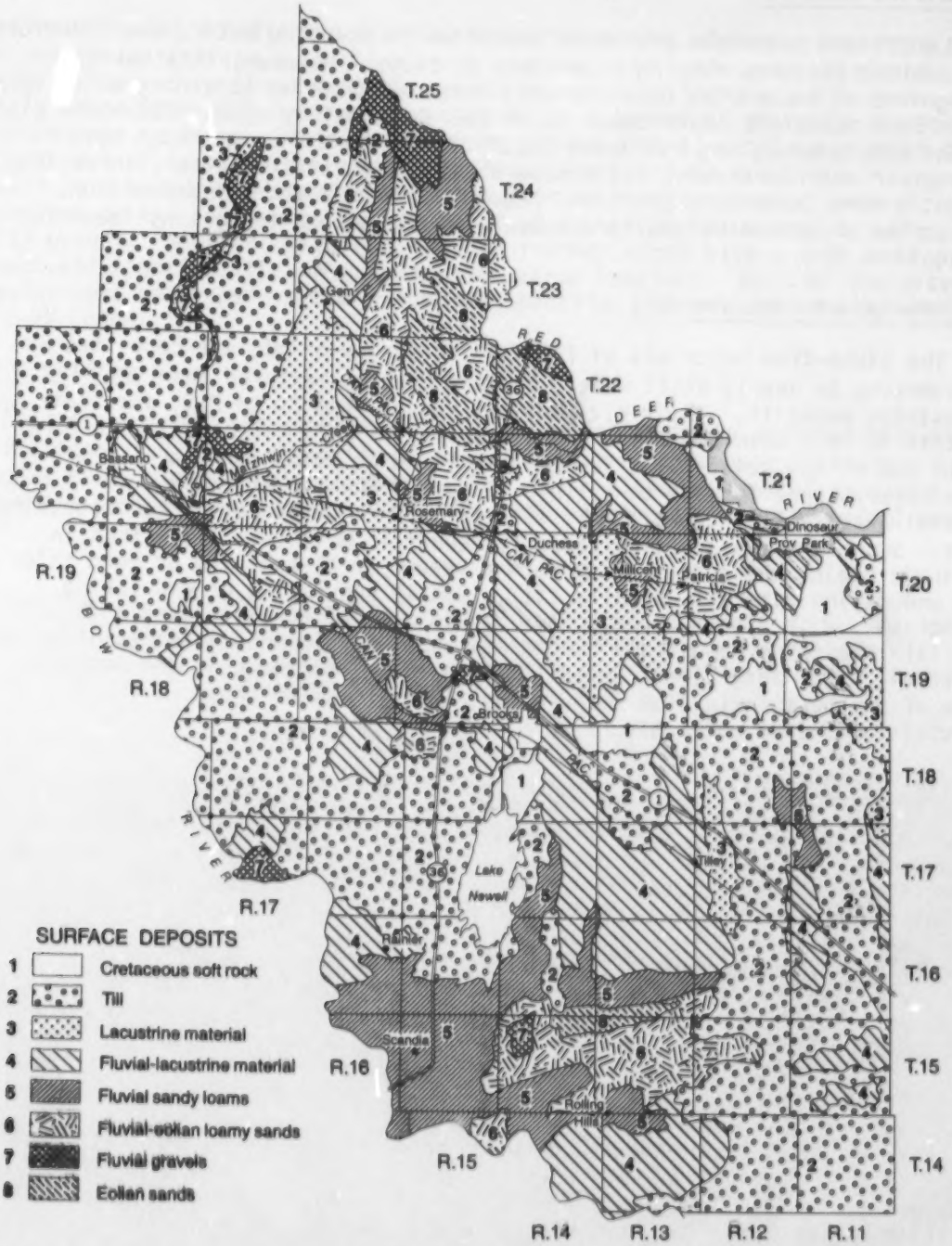



Figure 9. Surficial deposits in the County of Newell.

## Lacustrine materials

Lacustrine materials are those deposited in standing water, and therefore can include textures ranging from sands to clays. However, this survey recognizes as lacustrine deposits only those with a clay content greater than 35%. Such materials cover about 6% of the area, mainly within Matzhiwin Plain in the Gem-Rosemary and Millicent localities (Figure 9). Although both Solonetzic and Chernozemic soils have developed on this material, there are slightly more Solonetzic profiles. Because of their mode of deposition, lacustrine areas are naturally endowed with the smooth topography ideal for irrigation.

## Fluvial-lacustrine materials

The stone-free materials of fluvial-lacustrine origin are deposited by slow-moving to nearly still water, and are coarser textured than the lacustrine deposits. Their clay content ranges from 20 to 25%, and their sand content is less than 50%. The great majority of this material (which forms about 20% of the total area, Table 4) is found in Matzhiwin Plain, particularly from Duchess to Tilley. Figure 9 shows that these fluvial-lacustrine areas often form borders or companion areas to lacustrine ones. Such deposits are significantly deeper in Matzhiwin Plain than in Kininvie Plain, where they often form a veneer or blanket 1 m or more thick on the underlying material, usually till. Gently undulating or undulating topography, with slopes of less than 5%, is most often associated with fluvial-lacustrine deposits. Chernozemic soil development is dominant on this material, comprising almost twice the area of Solonetzic soil development. Some of the best irrigation soil in the EID is found on these fluvial-lacustrine materials.

## Fluvial sandy loams

Fluvial sandy loams are stream-deposited materials with a sand content greater than 50% and a clay content not exceeding 20%. These materials, which cover about 12% of the county, are most widespread in Matzhiwin Plain and the western portion of Kininvie Plain. In Matzhiwin Plain they are relatively deep, whereas in western Kininvie Plain they usually form a veneer or blanket over till. Although most of these fluvial deposits have developed a chernozemic type of profile, some areas have a solonetzic type. The most frequently occurring slopes are in the range of 2-5%, although more steeply sloping topography may be found on this material in some areas.

## Fluvial-eolian loamy sands

The designation fluvial-eolian loamy sands is applied to material that, subsequent to stream deposition, was partially reworked by wind resulting in a weakly expressed eolian landform on a fluvial plain. Although slopes are mostly 2-5%, both smoother and steeper slopes exist. The material has a sand content greater than 70% and a clay content of less than 10%. Most of this fluvial material, which covers about 10% of the county, is found in Matzhiwin Plain where it is considerably deeper than the lesser amounts found in Kininvie Plain. Soil development is primarily that characteristic of the Chernozemic order, with Solonetzic soils being less widespread.

## Fluvial gravels

Since fluvial gravels are deposits from fast-moving streams, they have a high gravel content and a low fine earth content. A little over 1% of the county is covered by these deposits, which occur in relatively small areas usually associated with major stream channels. A number of gravelly terraced landforms are confined within the Crawling Valley glacial spillway. About 9 km northeast of Bassano this glacial spillway empties into Matzhiwin Plain, depositing a variety of fluvial materials over an area stretching several kilometres to the southeast. At the point of discharge these deposits are mostly gravel. However, materials carried farther along have a high sand content and significantly more of the fine earth fraction. Most of the gravel deposits have developed a weak chernozemic profile. Slopes are usually within the 2-9% range.

## Eolian materials

Eolian materials are wind-deposited sands which probably originated from fluvial deposits. They generally have an irregular-shaped dune landform with a weakly expressed easterly alignment (Fig. 10). Although most of the sand dune areas in the county have slopes of 5-15%, some areas have steeper slopes.

Figure 10. Duned landform - Antelope series.

Slightly more than 3% of the county is covered by eolian deposits, mainly concentrated in two areas within Matzhiwin Plain (Figure 9). The most extensive area of sand dunes, lying northwest of Duchess, is used as native pasture. The dunes in the second area, located north of Rolling Hills, generally have a lower relief than those in the first. Since little or no profile has developed on these dune sands, they are classified as Regosolic soils.

# PART II. THE SOILS

## METHODS OF SURVEY

Soil survey is the systematic delineation of land areas in which the soils, their associated properites, and topography are all characterized within defined limits, as outlined by the Canada Soil Survey Committee (6). It is a specialized endeavor which follows rules of procedures set at biennial meetings of Canadian pedologists. Although such procedural rules ensure that the concept of soil is applied uniformly throughout Canada, each pedologist still must define limits for certain features or concepts that bear a direct relationship to the prescribed or best use of the soils in that area. Such procedures ensure uniformity of mapping throughout a map area and facilitate the compilation of the map legend.

## FIELD PROCEDURES

The soil series is the basic component, or mapping unit, used in this soil survey. Individual soil series are given a name, usually taken from a named feature (town, post office, river, lake, etc.) in the vicinity where the soil is first identified. Soil mapping is the technique of delineating areas with similar soil characteristics, either as areas of one series or as areas of associated soil series.

The soil survey of the County of Newell was started during the 1950's. At that time soil survey and salinity investigations on the irrigated lands of the Eastern Irrigation District resulted in two internal reports, one covering the Tilley area (4) and one covering the Patricia-Millicent area (10). In addition, soil maps covering the remainder of the irrigated land were made available to the EID and other interested agencies. More recent surveys concentrated on mapping the dryland areas within the county, as well as correlating the information obtained from previous surveys. All surveys were conducted at the detailed reconnaissance level, using a scale of about 1:63 000. However, the inspection was carried out in greater detail and at closer intervals on irrigated lands than on dryland areas.

During the course of the soil survey, all roads and trails within the county were traversed. Along each traverse, soil pit observations were made at intervals not exceeding 0.8 km. Several soil examinations were made at each stop to determine the complexity of soil patterns and the relationship of soil and landscape features. At each stop, and between stops, information on the soil and its environment was recorded on field sheets. Frequent departures from the traverse lines were necessary, particularly in the irrigated areas, to determine soil and landscape features between traverses. Soil and topography boundary lines were determined along the traverse lines and extrapolated between lines using aerial photographs and visible landscape features.

This area is generally characterized by a complex soil pattern. During mapping, an effort was made to indicate this pattern by recording the presence of the dominant soil series as well as the more frequently occurring less

dominant series. However, on the final soil maps accompanying this report, cartographic restrictions have limited the number of series in any map area to the three most abundant series shown in order of their dominance. Thus, most map areas are identified by a map symbol showing two or three dominant series but not including the less dominant series which may be present. These less dominant series occupy less than 15% of a delineation.

During the course of the soil survey, when soil series, extent, and location were established, samples were collected from selected locations representing dominant soil series. These samples were subjected to various chemical and physical analyses to further characterize the soil series. Results obtained from these analyses are recorded in the Appendix of this report.

## SOIL FORMATION

A soil profile is the sequence of layers or horizons exposed in a vertical section of soil, revealing the combined effects of factors responsible for soil formation. Thus, soil is the product of climate, vegetation, and topography acting on the parent material over a period of time. The degree and variability of any or all factors and their interaction are reflected in the numerous kinds of soils that exist in any given area. Climatic influences are mainly through precipitation and temperature as well as wind and water erosion. Furthermore, climate determines the type of vegetative cover and degree of biological activity. Different plant species produce different plant residues, which in turn determine soil color. Topography governs drainage and moisture conditions, thus producing microclimatic variations which in turn produce variations in vegetative cover. Another major influence on soil formation is exerted by the parent material, especially with respect to its inherent variability in such characteristics as texture, salinity, and mineralogy.

Weathering processes produce many varied but observable and measurable soil characteristics such as color, structure, texture, and consistence, to name the more important ones. Color itself has little direct influence on the functioning of the soil, but a great deal can be inferred from color when considered with other observable features. Dark colors are the result of high organic matter content and indicate relatively high fertility. Reddish colors are the result of hydrated iron oxide and are usually associated with good drainage and well aerated soils. Shades of gray, brown, or yellow in a mottled arrangement are usually associated with soils that have poor drainage. Soils with light gray colors usually have a low iron content and are lacking in organic matter, indicating low fertility. Soil colors that result from soil development must not be confused with colors inherited from the parent material.

Soil structure (the way soil particles aggregate) is important as it influences productivity and various management practices. Other physical characteristics such as texture and moisture content, as well as chemical characteristics, help determine the type of structure in any given soil. Soil consistence (the ability of a soil to resist structural breakdown) is also important as it relates to various management practices.

Other features (clay films, concretions, carbonates, salts, reaction, coarse fragments, roots, and pores) of the soil profile can also be observed and measured, both quantitatively and qualitatively, and form a record of the extent and degree of weathering that has occurred. Thus, soil profiles can be divided horizontally into horizons based on the fact that weathering becomes less pronounced with depth. Fig. 11 depicts the major horizons into which a soil profile can be divided.

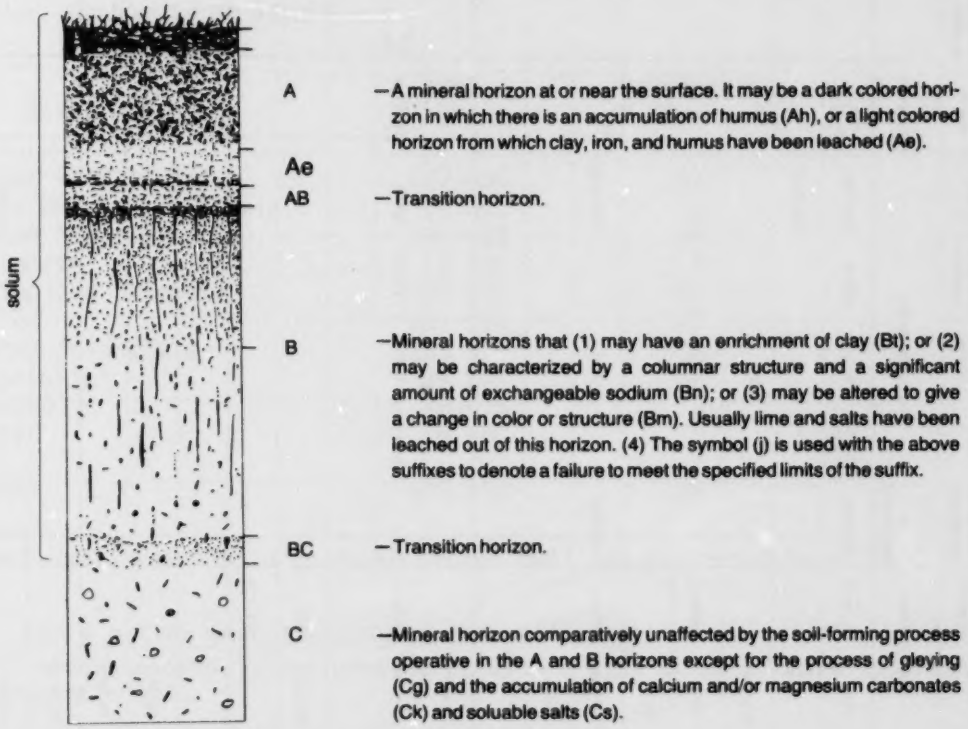

solum
A
—A mineral horizon at or near the surface. It may be a dark colored horizon in which there is an accumulation of humus (Ah), or a light colored horizon from which clay, iron, and humus have been leached (Ae).
Ae
AB
—Transition horizon.
B
—Mineral horizons that (1) may have an enrichment of clay (Bt); or (2) may be characterized by a columnar structure and a significant amount of exchangeable sodium (Bn); or (3) may be altered to give a change in color or structure (Bm). Usually lime and salts have been leached out of this horizon. (4) The symbol (j) is used with the above suffixes to denote a failure to meet the specified limits of the suffix.
BC
—Transition horizon.
C
—Mineral horizon comparatively unaffected by the soil-forming process operative in the A and B horizons except for the process of gleying (Cg) and the accumulation of calcium and/or magnesium carbonates (Ck) and soluable salts (Cs).

Figure 11. Diagram of a soil profile showing major horizons.

## SOIL CLASSIFICATION

Soil classification is the orderly arrangement (or grouping) of soil characteristics into categories according to the processes involved in their formation as displayed by the soil profile. During the soil survey of the County of Newell, soils were classified according to the guidelines established by the Canadian classification system (6). The 62 series that were recognized and mapped are arranged in Table 5 according to their relationship to the classification system and their parent materials.

Changes in the classification criteria between the period of mapping and writing have resulted in mixed terminology concerning soils that are intergrades between the Chernozemic and Solonetzic orders. Soils originally classed as Solodic Chernozemic were first changed to Eluviated Chernozemic, which is how they appear on the map legend. They are now classed as Solonetzic Chernozemic. The series involved are Cecil, Millicent, Tilley, and Timko.

Table 5. Key to Soils of the County of Newell

| CLASSIFICATION / TEXTURE / MATERIAL | | | CRETACEOUS SOFT ROCK | WEAKLY CALCAREOUS TILL | | LACUSTRINE | FLUVIAL-LACUSTRINE | | | FLUVIAL | | | FLUVIAL-EOLIAN | | | EOLIAN (DUNED) | FLUVIAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Deep | Veneer over till | Veneer over sands and gravels | Deep | Veneer over till | Veneer over fluvial-lacustrine | Deep | Veneer over till | Veneer over fluvial-lacustrine | | |
| | | | Medium | Moderately fine | Mod. fine to mod. coarse | Fine | Moderately fine | | Mod. fine to mod. coarse | Moderately coarse | | | Very coarse | | | Very coarse | Skeletal (gravel) |
| CHERNOZEMIC | BROWN | Orthic | | Maleb | Foremost | Seven Persons | Chin | Cranford | Ramillies | Bingville, Kangaroo | Antonio | Rainier | Cavendish | Purple Springs | | | Pemukan |
| | | Rego | | Helmsdale | | | | | | | | | Vendisant | | | | |
| | | Calcareous | | | | | Expanse | | | | | | | | | | |
| | | Solonetzic* | | Cecil | | Millicent | Tilley | Timko | | | | | | | | | |
| | | Solonetzic | | Ronalaine | | | Chinz | | | | | | | | | | |
| | DARK BROWN | Orthic | | Hughendon | | | Lethbridge | Whitney | Crowfoot | | Dolcy | | Wainwright | | | | Scollard |
| | | Calcareous | | | | | Chokio | | | | | | | | | | |
| | | Solonetzic | | Flagstaff | | | | | | | | | | | | | |
| SOLONETZIC | SOLONETZ | Brown | | | | Sterling | Bullpound | | | | | | | | | | |
| | SOLODIZED SOLONETZ | Brown | Steveville | Hemaruka | | Patricia | Wardlow | Duchess | | Youngstown | Gopher | Rolward | Yarmley | Sunnynook | Rolling Hills | | |
| | | Dark Brown | | Halkirk | | | | | | | | | | | | | |
| | SOLOD | Brown | | Halliday | | Rosemary | Karlsbad | Gem | | | | | | | | | |
| | | Dark Brown | | Brownfield | | | | Kirkcaldy | | | | | | | | | |
| REGOSOLIC | REGOSOL | Orthic | | | | | | | | | | | | | | Antelope | Etzikom |
| | | Orthic (Saline) | | | | | Scotfield | | | | | | | | | | |
| | | Cumulic | | | | | Verdigris | | | | | | | | | | |
| GLEYSOLIC | GLEYSOL | Orthic | | | | | Illingworth | | | | | | | | | | |
| | | Rego | | | | Walsh | Ventre | | | | | | Islands | | | | |
| | | Rego (Saline) | | Kitsim | | Gleddies | Dishpan | | | | | | | | | | |

* Formerly Eluviated Brown

A general summary of how the soils were classified (Table 6) indicates that most of the soils were classified as either Chernozemic or Solonetzic with lesser but significant amounts in the Regosolic and Gleysolic orders. The areal distribution of the soils, at the great group level, is shown in Fig. 12. Because of the general nature and scale of this figure, it was not possible to include the many small Gleysolic areas which in total cover about 3% of the county area.

Table 6. Soil Distribution at the Great Group Level in the County of Newell

| Soil | Area (ha) | Percentage of total area |
|---|---|---|
| Brown Chernozemic | 287 235 | 47 |
| Dark Brown Chernozemic | 19 050 | 3 |
| Total Chernozemic | 306 285 | 50 |
| Solonetz | 3 725 | 1 |
| Solodized Solonetz | 125 050 | 20 |
| Solod | 107 095 | 17 |
| Total Solonetzic | 235 870 | 38 |
| Regosolic* | 35 895 | 6 |
| Gleysolic | 18 415 | 3 |
| Water | 16 470 | 3 |
| Total | 612 935 | 100 |

*Includes areas mapped as rough broken (RB) and disturbed land (DL).

For a better understanding of the soils, a brief description of the four soil orders mapped is included here, with a list of their more important characteristics.

Chernozemic order

1 - contains up to 17% organic carbon in the A horizon
2 - has a C:N ratio of less than 17 in the A horizon
3 - has a high base saturation in the A horizon
4 - has calcium as the dominant exchangeable cation
5 - has a brownish solum
6 - is relatively friable in all horizons
7 - is well to imperfectly drained
8 - has developed under a Stipa-Bouteloua-Agropyron grassland community
9 - has a mean annual soil temperature of 0-5.5°C

Solonetzic order

1 - has a hard impermeable B horizon
2 - has strong columnar or prismatic structure in the B horizon
3 - has dark coatings on peds in the B horizon
4 - has a Ca:Na ratio of 10 or less in the B horizon
5 - usually has a neutral to acid A horizon
6 - is associated with saline parent materials high in Na
7 - has developed under a Bouteloua-Agropyron grassland community

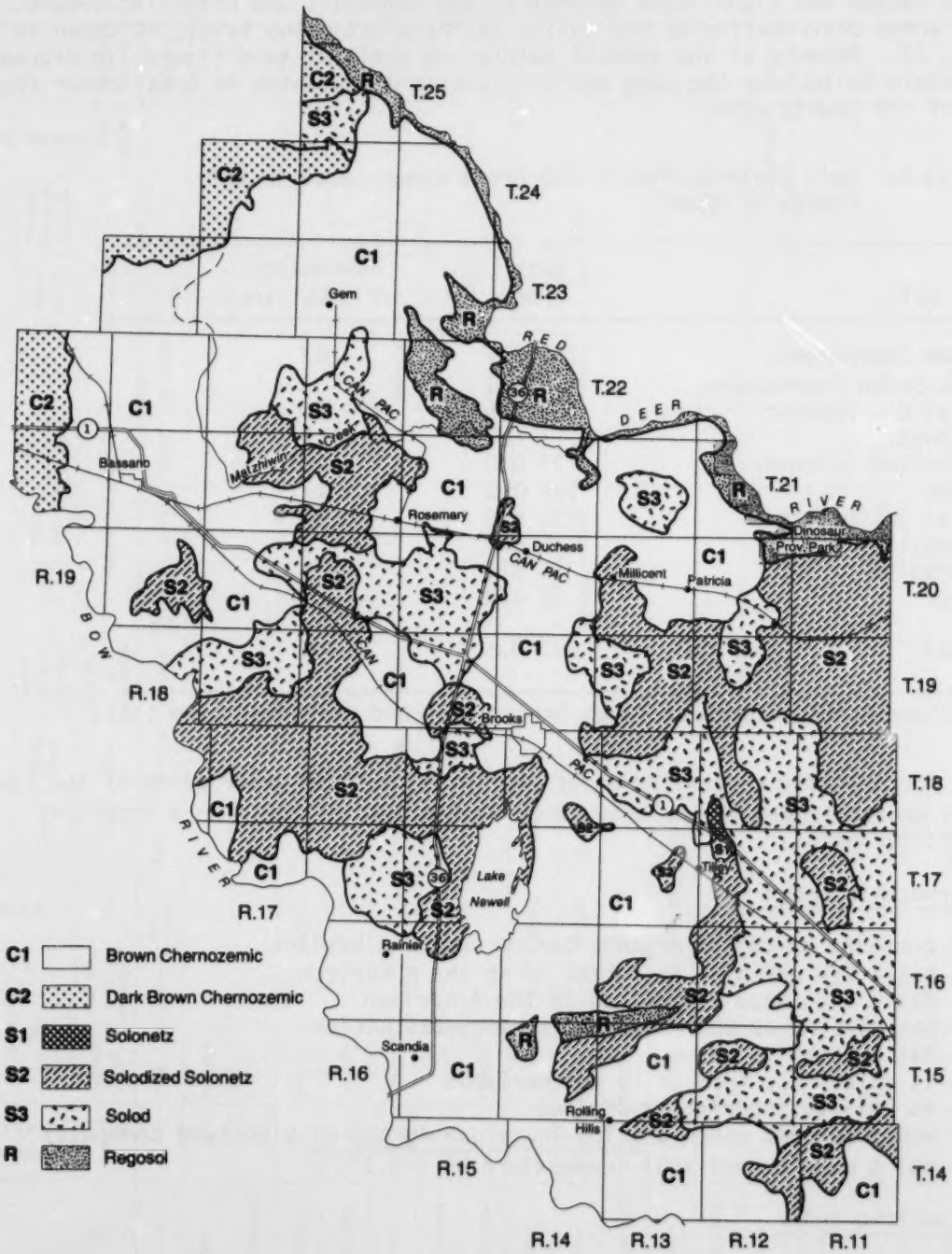



Figure 12. Generalized soil map at the great group level.

Regosolic order

1 - has weak to no profile development
2 - has no structural development
3 - is rapidly to imperfectly drained
4 - has variable vegetative cover

Gleysolic order

1 - occupies a depressional position in the landscape
2 - has dull soil colors with mottles indicative of gleying
3 - has soil horizons that are often indistinct
4 - supports hydrophytic vegetation

Although soils belonging to the four orders are found throughout the county, there is nevertheless a certain pattern or relationship between general soil types, physiographic districts, and parent materials. For example, on Crawling Valley Upland with its deep mantle of till derived from the Horseshoe Canyon formation, the soils are primarily Orthic Chernozemic. In contrast, eastern Kininvie Plain has a thin to absent mantle of till over the saline soft rock materials of the Bearpaw formation, resulting in an area of predominantly Solonetzic soils. These relationships are most obvious with the Chernozemic and Solonetzic soils because of their greater occurrence; in the other physiographic districts such relationships, although present, are much less obvious. The relationships are presented in a general way in Table 7. Gleysolic soils are not included in this table as their occurrence is mainly associated with depressional topography and not with the characteristics of the physiographic district.

Table 7. Relationships between Physiographic Districts, Soils, and Parent Materials

| Physiographic district | Soil classification | Parent material |
|---|---|---|
| Crawling Valley Upland | Chernozemic | Till |
| | Dominant Chernozemic | Mixed fluvial and lacustrine |
| Matzhiwin Plain | Significant Solonetzic | Mixed fluvial and lacustrine |
| | Some Regosolic | Eolian |
| Chin Plain | Chernozemic | Mixed fluvial and lacustrine |
| Kininvie Plain (west) | Solonetzic and Chernozemic about equal | Mainly till, some over soft rock |
| Kininvie Plain (east) | Solonetzic | Till veneer over soft rock |

## DESCRIPTION OF THE SOILS

It is not the intention of this report to provide a detailed description of each of the 62 soil series mapped in the County of Newell. Rather, those selected will be on the basis of occurrence, since more than 80% of the area is covered by 27 soil series. Thus, with few exceptions, only the soil series that cover 1% or more of the total area will have a detailed soil profile description included in the Appendix of this report along with the analytical data. The remaining 35 series will be described in general terms only.

Discussion and information on each series are presented in the alphabetical order of their map symbols. Some comments will be included relative to landscape features associated with each series, as well as their use potential, particularly with respect to agriculture. Anyone desiring more information on the soils than that included in this report may obtain it from the Alberta Soil Survey.

### Antonio series (map symbol Ao)

Detailed information in Appendix
Extent - 9435 ha (1.52% of total area)
Classification - Orthic Brown Chernozemic
Usual surface texture - sandy loam
Major associated series - Bingville, Maleb
Parent material - coarse loamy, fluvial veneer over till
Associated landform - undulating
Slope range - 2-15%
Drainage - rapidly to well drained
Agriculture capability - 4 m
Irrigation rating - fair
Grazing carrying capacity - 16-19 ha/AUY*

Antonio soil is distinguished by the presence of 20-100 cm of a brownish stone-free sandy loam, which overlies a clay loam till. In addition to its weak structure and associated loose consistence, the upper material usually has a mildly alkaline to neutral reaction. The underlying till is similar to that which forms the parent material for many soils in the county. Surface features usually reflect the contour of the underlying till.

The relationships that occur between the Antonio series and the associated Bingville and Rainier series are illustrated in Fig. 13. Most of the soils mapped as Antonio are associated with other fluvial deposits within Matzhiwin Plain and a significant portion of Chin Plain, south of Lake Newell.

*hectares per animal unit, per year.

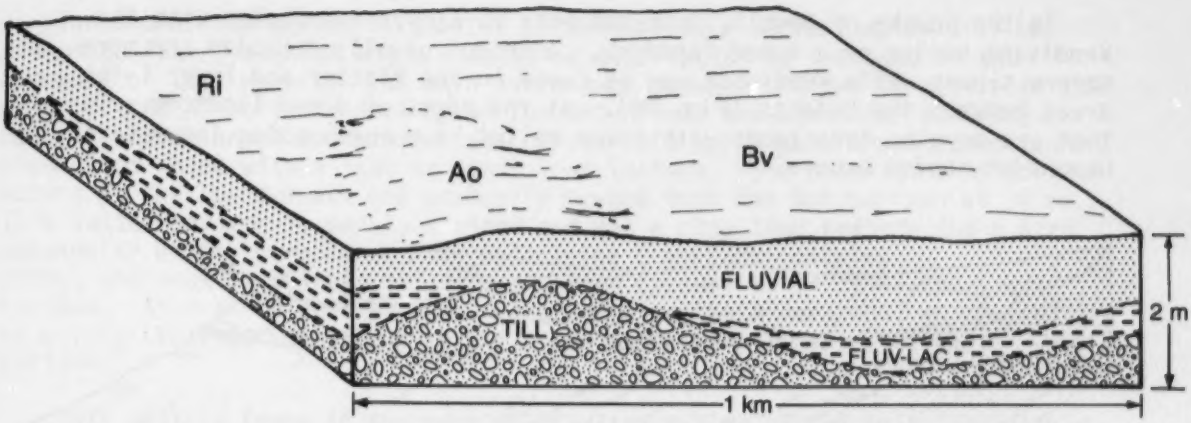



Figure 13. Cross-sectional diagram showing the Antonio series and some of its associated soils.

Because of the coarse textured upper material, this soil has a relatively low water-holding capacity, which is to a certain extent offset by the less permeable underlying till. Downward-percolating precipitation is partially arrested at the fluvial-till interface thus reducing losses of moisture and making it more available to plants. Under irrigation, Antonio soils have a high potential for lateral seepage because of the less permeable underlying till. The coarse texture of this soil makes it highly susceptible to wind erosion, so proper cultural practices should be used to reduce this hazard.

Antelope series (map symbol Ap)

Detailed information in Appendix
Extent - 12 380 ha (2.02% of total area)
Classification - Orthic Regosol
Usual surface texture - sand
Major associated series - Vendisant, Cavendish
Parent material - sandy eolian
Associated landform - duned
Slope range - 2-15%
Drainage - rapidly drained
Agricultural capability - 6 m
Irrigation rating - non-irrigable
Grazing carrying capacity - 32-49 ha/AUY

The main distinguishing feature of the Antelope series is its sandy texture and lack of profile development, except for a very weakly developed and thin Ah horizon. Brownish colors persist well below the surface and gradually become grayer with depth. Because of the very low clay content and lack of organic matter, these sands are very loose. A neutral reaction, which further characterizes the upper part of the profile, gradually yields to mildly alkaline conditions below the 1-m depth.

In the County of Newell, Antelope soil is always associated with the Vendisant series on a duned landform. Antelope usually occupies the more severe slopes while Vendisant can be found in the flatter and lower lying areas between the heights (Fig. 14). At the edges of duned landform areas that are merging into lands with lower relief, a corresponding increase in the Cavendish series occurs.

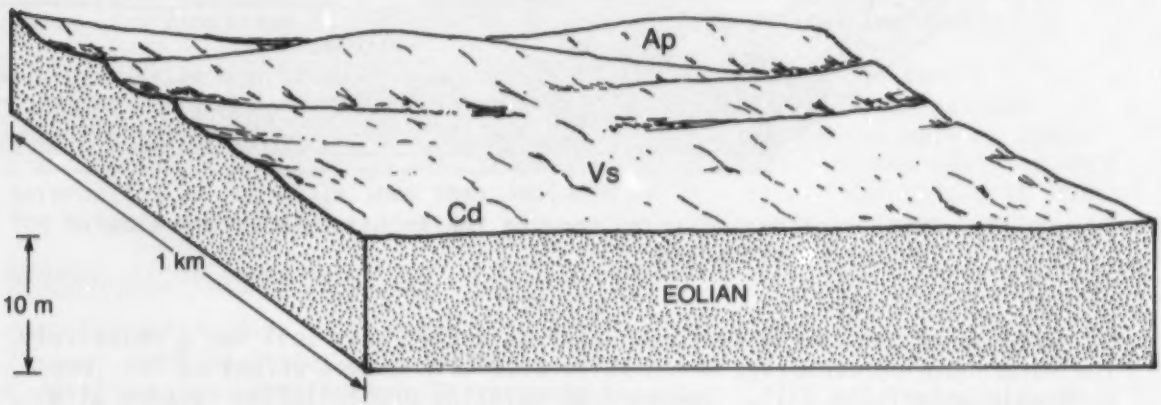



Figure 14. Cross-sectional diagram showing landform and soil relationships between the Antelope series and its associated soils.

North and west of Duchess, Highway 36 traverses an extensive dune area associated with Red Deer River and its tributary, Matzhiwin Creek. Smaller duned areas also occur a few kilometres north of Rolling Hills and along Bow River southwest of Lake Newell. Although the dunes in the county display a somewhat irregular pattern, they have a fairly definite linear configuration indicative of prevailing winds at the time of deposition. It is interesting to note that the more northerly dunes are generally aligned northwest-southeast whereas those in the southern part of the county lie more west-east.

To avoid serious wind erosion, Antelope soil areas should be left in their native state and should not be cultivated. They have limited use as native pasture, but overgrazing could easily destroy any established grass cover resulting in active dune formation.

Brownfield series (map symbol Bf)

Extent - 3760 ha (0.61% of total area)
Classification - Dark Brown Solod
Usual surface texture - loam
Major associated series - Halkirk, Flagstaff
Parent material - fine loamy till
Associated landform - undulating and hummocky
Slope range - 2-15%
Drainage - moderately well drained
Agricultural capability - 3 d
Irrigation rating - poor
Grazing carrying capacity - 12-16 ha/AUY

The Brownfield series is similar to the Halliday series, which will be discussed later, and for which a detailed description is included in the Appendix of this report. The main difference between the two series is in the color of the Ah horizon: dark brown for Brownfield and brown for Halliday. Below the dark brown surface horizon, Brownfield has a pale brown Ae horizon about 4 cm thick with a loam to sandy loam texture. The transition AB horizon occurs at the 15-cm depth and gradually merges into the Bnt horizon at 24 cm. This latter horizon is darkly stained and has a clay loam texture and a hard subangular blocky structure. The underlying C horizon contains $CaCO_3$, and usually sulfate salts (most often gypsum) at or below the lime horizon. Neutral to acid pH values characterize the A horizons, which yield to mildly alkaline conditions in the B and moderately alkaline in the C horizon.

This soil is found in the part of Crawling Valley Upland that lies within the Dark Brown soil zone along the northwestern edge of the county. Because that part of the county is dominated by Chernozemic soils, the Brownfield series is found primarily as a minor component of the map unit with the Flagstaff and Hughendon series. However, in the small Solonetzic area in the northern part Brownfield is the dominant soil, in association with Halkirk and Flagstaff. A similar relationship exists between Brownfield, Halkirk, and Flagstaff as that shown in Figure 16 between Halliday, Hemaruka, and Cecil, the brown counterparts of these three soils.

Although not severe, some limitations are associated with the use of this soil for dryland agriculture. These are related to the solonetzic characteristics of the B horizon, which become even more limiting if the soil has a thinner than normal Ah horizon. In this area there is no evidence of abnormally low pH values in the Ah of Brownfield soil; however, the so-called "acid Solod" phenomenon has been found elsewhere on the same soil.

Brownfield soils are considered to be poor for irrigation, again because of the solonetzic B horizon. Under irrigation, saline surface conditions may develop from the saline parent materials. Although some stones are usually present in this soil, they are not sufficient to hinder cultivation.

Bullpound series (map symbol Bl)

Extent - 405 ha (0.07% of total area)
Classification - Brown Solonetz
Usual surface texture - silt loam
Major associated series - Wardlow, Karlsbad, Dishpan
Parent material - fine loamy fluvial or lacustrine
Associated landform - level and undulating
Slope range - 0.5-5%
Drainage - moderately well drained
Agricultural capability - 5 d
Irrigation rating - non-irrigable
Grazing carrying capacity - 24-32 ha/AUY

Bullpound soils are distinguished by their thin Ah and hard solonetzic B horizons. The thin Ah, usually 3 cm or less thick, is dark grayish brown often becoming grayer at the lower boundary. The change to the Bnt horizon is abrupt. This horizon has a clay loam to clay texture and a very hard columnar

structure. Clay content decreases slightly with depth to a fairly uniform silty clay loam in the parent material. Colors of the B horizon are usually very dark grayish brown and grade to a dark yellowish brown, with a corresponding softening of the structure, in the lower B horizon. A $CaCO_3$ horizon usually occurs at or below 60 cm. Salts are usually encountered at these lower depths as well. Neutral to acid conditions are found at the surface, whereas mildly alkaline conditions prevail in the B horizon. A gradual increase in alkalinity occurs with depth.

In this county the majority of Bullpound soils are found in, or associated with, broad drainage channels, which may or may not contain an active stream (Fig. 15). Since these channels usually have a relatively high water table, it is common to find gleyed conditions in the lower portions of Bullpound soil. Sometimes the lower parts are groundwater discharge areas, so that Bullpound soils or their associated soils are often salinized. The Bullpound soils mapped most often occurred as a minor component of the map unit, usually associated with Solonetzic soils of the same parent materials, namely Wardlow and Karlsbad; or with Dishpan, the saline Rego Gleysol. The typical sequence in a fluvial-lacustrine area with Solonetzic soils is shown in Fig. 15, where Bullpound occupies the lower, less well drained position in the landscape.

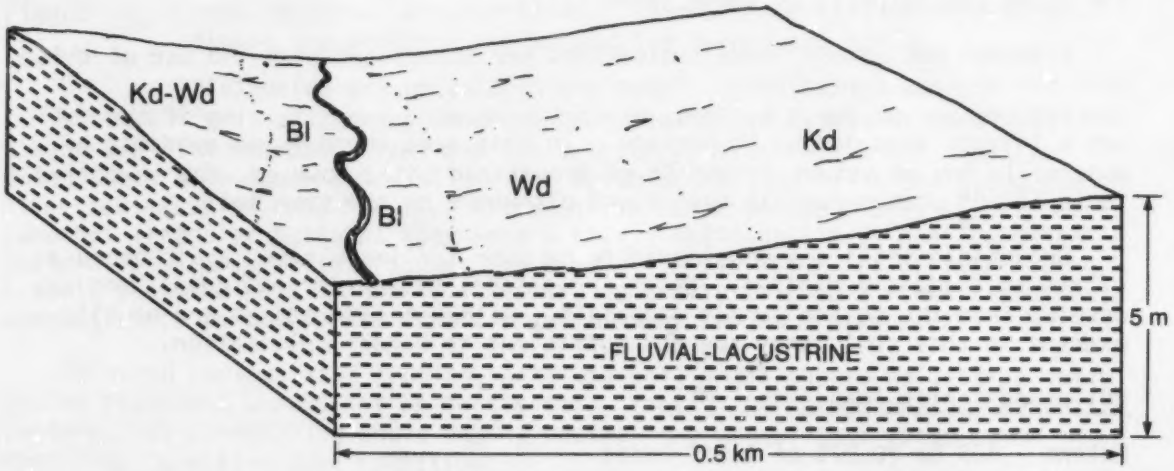



Figure 15. Cross-sectional diagram of a typical toposequence associated with the Bullpound series.

Primarily because of its solonetzic characteristics and the very thin Ah, this soil should not be considered for cultivated agriculture, either dryland or irrigated. Its best agricultural use is pastureland.

Bingville series (map symbol Bv)

Detailed information in Appendix
Extent - 35 965 ha (5.8% of total area)
Classification - Orthic Brown Chernozemic
Usual surface texture - sandy loam
Major associated series - Cavendish, Chin, Antonio, Rainier
Parent material - coarse loamy fluvial
Associated landform - undulating and low-relief hummocky
Slope range - 2-9%
Drainage - rapidly drained
Agricultural capability - 4 m
Irrigation rating - fair
Grazing carrying capacity - 16-24 ha/AUY

Deep sandy loam materials and brownish colors are typical of Bingville soils. An Ah horizon about 15-25 cm thick grades into a dark yellowish brown Bm horizon, which like the Ah is of sandy loam. This texture continues through the pale brown $CaCO_3$ horizon, at about 60-70 cm, into the paler brown lower horizons. Relatively weak structures persist through the entire profile. Slightly acid to neutral pH values in the upper horizons turn to mildly alkaline conditions in the lime horizon and below.

It should be noted that the Ah colors given in the detailed description are somewhat darker than normal. This can be attributed to an increased organic matter content through several years of irrigation. The description also divides the Ah horizon into three subhorizons, which is unusual because normally there are insufficient differences to warrant separation. Textures usually are somewhat finer than those given in the detailed description. However, it is not uncommon to find even coarser textures at the 1-m depth or lower.

Bingville soils are widespread in both Matzhiwin and Chin plains, where they are found in association with a variety of soils, either as the dominant member or as a minor component of the map unit. Probably the most frequent association is with Cavendish soil in areas of coarse fluvial deposits. In areas where the coarse loamy fluvial material of Bingville soil is closely associated with fine loamy fluvial-lacustrine material, the main associated soil is Chin. In many locations where a veneer or blanket of coarse loamy material overlies till, the associated soils are Antonio and Maleb. Bingville has also been mapped in association with the Rainier series in the Scandia-Rainier area where a veneer or blanket of sandy loam overlies fluvial-lacustrine material. This is illustrated in Figure 13.

Elsewhere, varying depths of sandy loam are overlaid on till in which a solonetizc Bnt has developed, resulting in mapping units that include the Gopher series. A similar situation exists in the vicinity of Rolling Hills hamlet, where solonetzic development has taken place in fluvial-lacustrine material and the Bingville series is associated with the Rolward series. In an area north of Bassano, a gravelly phase of the Bingville series has been mapped in various combinations with the Foremost and Pemukan series. Fairly

extensive areas of Bingville have been mapped immediately north and east of San Francisco Lake, about 15 km west of Brooks. Located in the western part of Kininvie Plain, this is the only major area of sandy soils outside either Matzhiwin or Chin plains.

For dryland agriculture, Bingville soils are generally considered to be marginal because of their coarse texture and associated low water-holding capacity and wind erosion hazard. However, under irrigation the coarse texture is less limiting to crop production.

Cecil series (map symbol Cc)

Detailed information in Appendix
Extent - 36 465 ha (5.95% of total area)
Classification - Solonetzic Brown Chernozemic (formerly Eluviated Brown)
Usual surface texture - loam
Major associated series - Maleb, Halliday, Ronalaine, Cranford, Hemaruka
Parent material - fine loamy till
Associated landform - undulating and hummocky
Slope range - 2-20%
Drainage - well drained
Agricultural capability - 4 m
Irrigation rating - good
Grazing carrying capacity - 14-19 ha/AUY

The typical Cecil soil has a fairly distinct grayish brown platy Ae horizon between the Ah and B horizons. A significant amount of illuviated clay is present in the B horizon, which has a more distinct subangular blocky structure than Maleb, the Orthic Brown Chernozemic on similar parent material. The B horizon (15-20 cm thick) is underlain by a moderately calcareous horizon which grades into a weakly calcareous C horizon at about the 50-cm depth. Salts are sometimes encountered at the lower depths. Except in the A horizon, loam to clay loam textures persist throughout the profile. The A horizons usually have pH values near neutral with mildly to moderately alkaline values prevailing in the subsoil. The detailed description of the Cecil profile included in the Appendix of this report has a somewhat thinner solum than normal. Usually the Bt horizon is a few centimetres thicker and is underlain by a BC horizon. Often the Cecil profile has a less discernible Ae horizon than that described so that it is difficult to distinguish from the Maleb profile, which is very similar but has no Ae and a less pronounced structure in the B horizons, as mentioned earlier.

In Crawling Valley Upland this soil is confined to the portion within the Brown soil zone, where it is mainly associated with the Maleb series as either the major or minor component of the map unit. It can be found on a wide range of topographic positions and slopes in this upland region. In the western part of Kininvie Plain, Cecil is often associated with Halliday and Hemaruka soils and normally occupies the midslope position (Fig. 16). Maleb is again the major associated soil in the Chernozemic portions of the plain along Bow River. It is less extensive in the eastern portion of Kininvie Plain where it appears mainly as the minor map unit component with Halliday, Hemaruka, and

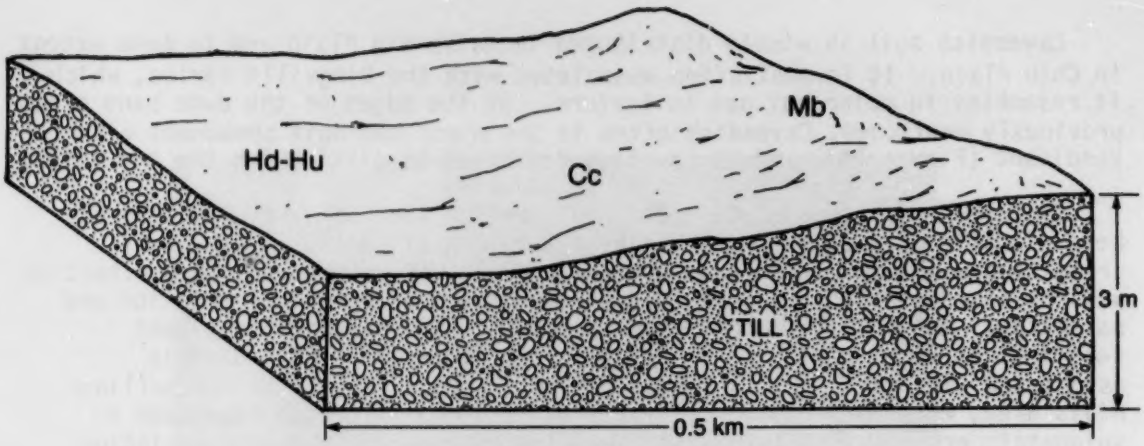



Figure 16. Cross-sectional diagram of a typical toposequence associated with the Cecil series.

sometimes Ronalaine. Cecil occurs infrequently in Matzhiwin Plain, where it is found in some of the isolated areas where till occurs at the surface. In these locations it is usually associated with the Cranford series.

There are no major soil limitations to the use of the Cecil series for agriculture, except that the region has low rainfall. The rough topography on which it is often found places a very severe limitation on its use for cultivated agriculture, particularly irrigated agriculture. For this reason, many areas where Cecil occurs are used for grazing. In some locations stones may present a problem for cultivation.

Cavendish series (map symbol Cd)

Detailed information in Appendix
Extent - 43 385 ha (7.08% of total area)
Classification - Orthic Brown Chernozemic
Usual surface texture - loamy sand
Major associated series - Bingville, Vendisant, Purple Springs
Parent material - sandy fluvial or eolian
Associated landform - undulating and ridged
Slope range - 2-15%
Drainage - rapidly drained
Agricultural capability - 5 m
Irrigation rating - fair
Grazing carrying capacity - 24-32 ha/AUY

A typical Cavendish soil has a brownish solum developed in structureless and loose loamy sand to sand. The gradual change from one horizon to another is mainly in color, which grades from a dark grayish brown surface horizon through a brown B and into a pale brown C horizon. Usually, pH values increase with depth from slightly acid to neutral in the surface horizon to neutral in the B horizon and neutral to mildly alkaline in the C horizon. If a $CaCO_3$ horizon is present it is usually near the 1-m depth or below. The Appendix of this report describes a Cavendish profile which has a coarser texture than is normal for this soil and has a darker than normal Ah horizon.

Cavendish soil is widely distributed in Matzhiwin Plain and to some extent in Chin Plain. It is most often associated with the Bingville series, which it resembles in color but not in texture. At the edges of the dune sand areas previously mentioned, Cavendish often is the minor map unit component with Vendisant (Figure 14), and it is often difficult to distinguish the two soils.

The widespread area of Cavendish soil around the hamlet of Patricia has been significantly salinized and gleyed by years of lateral movement of irrigation water over the underlying finer textured material. (This situation will be discussed in more detail in the section dealing with irrigation and salinity.) Many similar areas exist where the thickness of loamy sand sometimes is less than 1 m, resulting in map units where Cavendish is associated with the Purple Springs series. Another example is the Rolling Hills area, where underlying materials at less than 1 m have developed a solonetzic profile. In this case Cavendish has been mapped in association with the Rolling Hills or Sunnynook series. In other areas, where a solonetzic profile has developed in deep sand deposits, the associated soil is the Yarnley series.

Cavendish soil areas, because of their coarser texture, should not be considered for dryland crop production requiring annual cultivation as this may result in severe wind erosion. Under irrigation, this soil has some potential where the depth to, and slope of, the underlying finer material are such that seepage and saline conditions do not occur.

Cranford series (map symbol Cf)

Detailed information in Appendix
Extent - 9595 ha (1.57% of total area)
Classification - Orthic Brown Chernozemic
Usual surface texture - silt loam
Major associated series - Chin, Maleb
Parent material - fine loamy fluvial or lacustrine veneer over till
Associated landform - level, undulating, and low-relief hummocky
Slope range - 0.5-9%
Drainage - well drained
Agricultural capability - 4 m
Irrigation rating - good
Grazing carrying capacity - 14-19 ha/AUY

Cranford soils are distinguished by 20-100 cm of fluvial or lacustrine material overlying till. This stone-free overlay generally has silt loam textures and brownish colors in the A and B horizons. These colors grade to yellowish brown in the BC horizon and lower. The underlying till is similar to that found elsewhere in the County of Newell. Neutral pH values in the surface material increase to mildly alkaline conditions in the B horizon and moderately alkaline conditions in the remainder of the solum. A typical Cranford soil is described in the Appendix of this report, and is pictured in Fig. 17. Finer textures than those found at the described location are not unusual for this soil. Considerable variation occurs in the thickness of the overlay material, often thicker than in the profile described. Although not too common, a thin layer of coarse fluvial material sometimes separates the till from the overlying fluvial or lacustrine material. Cranford soils are similar to Chin soils except for the till within the 1 m depth.

Figure 17. Soil profile of the Cranford series.

Occurrence of Cranford soil is almost entirely limited to Matzhiwin and Chin plains. It is mainly associated with the Chin and Maleb series in fluvial-lacustrine areas adjacent to till areas, where the depth to underlying till is less than or greater than 1 m. A subdued hummocky landform often reflects the hummocky character of the underlying till surface. In areas where these three soils are found in association, one can usually expect to find Cranford soil on, or adjacent to, the higher points (Fig. 18). In most locations, Cranford has been mapped as the minor component of the map unit. However, this is not true in the Rainier area where the soil is often the major component in combination with a number of other soils.

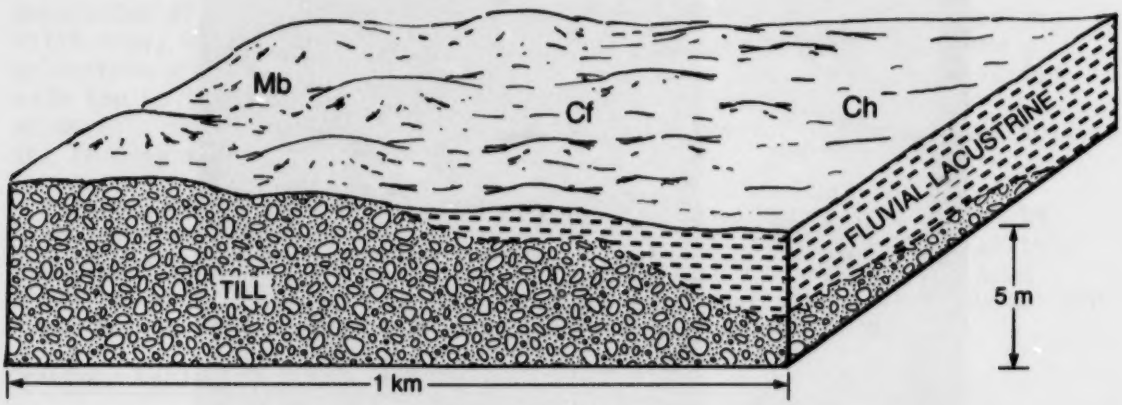



Figure 18. Cross-sectional diagram of a toposequence associated with the Chin-Cranford-Maleb complex.

Like all soils in this region, Cranford soil has limitations for dryland farming caused by the low rainfall. For irrigation, however, it has a much greater potential. Seepage problems may arise under irrigation, particularly where the overlay material is significantly more permeable than the underlying till. This problem is even more serious in Cranford soils that have a coarse fluvial layer above the till because this enhances lateral water movement and increases the possibility of seepage.

Crowfoot series (map symbol Cft)

Extent - 120 ha (0.02% of total area)
Classification - Orthic Dark Brown Chernozemic
Usual surface texture - loam to sandy loam
Major associated series - Scollard, Chokio
Parent material - fine to coarse loamy fluvial veneer over outwash
Associated landform - terrace
Slope range - 2-9%
Drainage - rapidly drained
Agricultural capability - 3 m
Irrigation rating - fair
Grazing carrying capacity - 12-16 ha/AUY

The most distinctive feature of Crowfoot soil is the gravelly and coarse sandy fluvial material which underlies the much finer fluvial material at the surface. Although it has a coarser texture, this upper material resembles the upper portion of the Lethbridge profile. An A horizon of dark brown loam to sandy loam gradually merges into a brown to dark brown B horizon at about 15 cm below the surface. It is not unusual to find coarse sand grains in the A and B horizons which have a gritty feel. The A horizon usually has a weak granular structure, and the B horizon a weak prismatic structure. The Cca horizon is usually encountered at approximately the 40-cm depth, and often has a higher $CaCO_3$ concentration than have other Chernozemic soils. An abrupt horizon boundary separates the two fluvial deposits. The underlying outwash material varies widely in its size fractions, ranging from sand to fragmental. Both the A and B horizons have a neutral reaction while the horizons below are alkaline. This soil is similar to Ramillies. The main difference is the color of their Ah horizons: dark brown for Crowfoot and brown for Ramillies.

Crowfoot soil was mapped only in the valley of the Bow River in the southwestern corner of the map area. There it is associated with a terraced landform characteristic of many river valleys. Although Crowfoot soil is associated only with Scollard and Chokio soils in the County of Newell, it can be found in association with the Lethbridge series elsewhere. Because of its coarse textured subsoil it tends to be rather droughty, which limits its potential for agricultural production.

Chin series (map symbol Ch)

Detailed information in Appendix
Extent - 29 995 ha (4.89% of total area)
Classification - Orthic Brown Chernozemic
Usual surface texture - silt loam
Major associated series - Tilley, Bingville, Cranford, Chinz
Parent material - fine loamy fluvial or lacustrine
Associated landform - level, undulating, and low-relief hummocky
Slope range - 0.5-9%
Drainage - well drained
Agricultural capability - 4 m
Irrigation rating - good
Grazing carrying capacity - 14-19 ha/AUY

A typical Chin soil can be recognized by its brown color and deep uniform silty fluvial or lacustrine parent material. Normally the Ah horizon is about 15 cm thick. It grades into a brighter brown and finer textured Bm horizon, which is also characterized by its prismatic structure. Below this, at about 40 cm, there is a $CaCO_3$ horizon usually of medium concentration. Silt loam textures are usual for these lower subsoils. Close to neutral pH values occur in the upper part of the profile, yielding to mildly alkaline conditions in the subsoils. The profile described in the Appendix has a slightly coarser texture in the C horizon than is normal for this soil. Furthermore, the laminated lower C horizon is an unusual feature.

Derived from fluvial or lacustrine deposits, Chin soils are usually found on fairly smooth topography associated with broad fluvial or lacustrine landscapes such as Matzhiwin and Chin plains. Within these plains there are several locations where Chin soils prevail. Perhaps the most extensive occurrence is in the Tilley area where Chin soils are mainly associated with Tilley soils, and to a lesser extent the Chinz, Karlsbad, and Bingville series. At the extreme southern part of the county, south of Rolling Hills, Chin has also been mapped in association with the Tilley series and several other Chernozemic soils. Another area where Chin soils have been extensively mapped is around and between Brooks and Duchess where the main associated soils are again Tilley, Chinz, and Bingville. Around Bassano, where the depth to underlying till is relatively shallow, this soil has been mapped in association with the Cranford and Maleb series, as illustrated in Fig. 18. In the Rainier area, Chin soils have been mapped in various combinations with the Bingville, Cranford, and Rainier series.

This soil is considered to be one of the best for irrigation, mainly because of its medium texture which continues uniformly with depth. However, even the best irrigation soil can be salinized by irrigation, as pictured in Fig. 19, which shows the tiny salt flecks present in a saline phase of Chin soil. For dryland agriculture, its only limitation is that it occurs in areas of low rainfall.

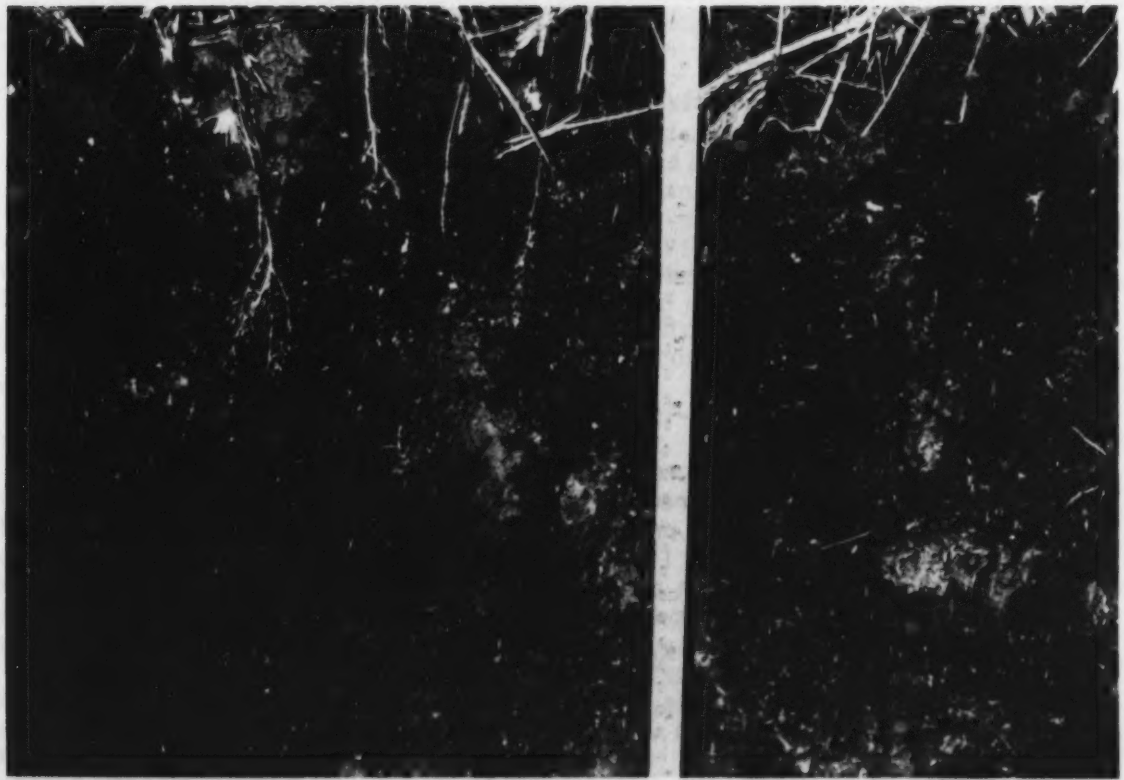


Figure 19. Soil profile of the Chin series, saline phase. Note the numerous small salt flecks.

Chokio series (map symbol Ci)

Extent - 120 ha (0.02% of total area)
Classification - Calcareous Dark Brown Chernozemic
Usual surface texture - silt loam
Major associated series - Lethbridge
Parent material - fine loamy fluvial or lacustrine
Associated landform - level, undulating, and low hummocky
Slope range - 0.5-9%
Drainage - well drained
Agricultural capability - 3 m
Irrigation rating - fair
Grazing carrying capacity - 10-12 ha/AUY

Chokio soil differs from Lethbridge soil with which it is most often associated mainly in that Chokio has $CaCO_3$ present in the B horizon, whereas Lethbridge does not. Loam and silt loam textures, which prevail in the upper part of the profile, usually become finer with depth. A weakly developed and friable prismatic structure can usually be found in the B horizon. Mildly alkaline conditions prevail throughout the profile, except for the A horizon where pH values are in the neutral range.

This soil was mapped only in the Bow River valley, upstream from Bassano Dam, where Lethbridge and Crowfoot series are the main associated soils. In this valley Chokio soil is primarily used for native pasture, even though it has a relatively high potential for both dryland and irrigated agriculture.

Chinz series (map symbol Cz)

Extent - 2630 ha (0.43% of total area)
Classification - Solonetzic Brown Chernozemic
Usual surface texture - silt loam
Major associated soils - Chin, Tilley
Parent material - fine loamy fluvial or lacustrine
Associated landform - level, undulating, and low-relief hummocky
Slope range - 0.5-9%
Drainage - well drained
Agricultural capability - 4 m
Irrigation rating - good
Grazing carrying capacity - 14-19 ha/AUY

The most distinguishing feature of the Chinz profile is the Solonetz-like structure of the B horizon. Although this structure is not as hard or as darkly stained as a true solonetzic B, it is considerably harder than a typical chernozemic B horizon. A typical Chinz profile has a few centimetres of brown silt loam above the Solonetz-like B horizon, which is usually dark brown silty clay loam. Subsurface textures are usually silt loam to silty clay loam in yellowish brown materials. A calcareous horizon occurs at about 35-40 cm below the surface. The pH values increase with depth, from neutral in the A horizon to mildly alkaline in the B and moderately alkaline in the C horizon. It is not uncommon to find some salts in the lower C horizon.

Almost all Chinz soils mapped occur within Matzhiwin Plain, particularly between Duchess and Brooks. Lesser amounts were mapped east of Lake Newell in an area south of Tilley. In most instances this soil was mapped as a minor component of the map unit, primarily in association with Chernozemic soils of a similar parent material, namely the Chin and Tilley series.

This soil has no major limitations to use for cultivated agriculture. In fact, the fine textured B horizon which usually is well within cultivation depth increases the water-holding capacity in the root zone of most cultivated crops. This soil is therefore more desirable for dryland agriculture than other Chernozemic soils of similar texture.

Dolcy series (map symbol Dc)

Extent - 200 ha (0.03% of total area)
Classification - Orthic Dark Brown Chernozemic
Usual surface texture - sandy loam
Major associated soils - Hughendon, Lethbridge, Chokio
Parent material - coarse loamy fluvial veneer over till
Associated landform - undulating and hummocky
Slope range - 2-15%
Drainage - rapidly to well drained
Agricultural capability - 3 m
Irrigation rating - fair
Grazing carrying capacity - 12-16 ha/AUY

In the Dolcy series, till is encounted at less than 1 m deep. All Dolcy soils have their A and B horizons in the fluvial overlay above the till, while only those with thicker overlays have a lime horizon above the till. Actually, this soil is very similar to the Antonio series, its brown counterpart, described in the Appendix. The main difference is in the color of their A horizons: dark brown for Dolcy and brown for Antonio.

Limited amounts of this soil were mapped at or near the western edge of the county, directly west of Bassano. Some were mapped in the river valley in association with the Lethbridge and Chokio series, and some in the upland till area, in association with the Hughendon series. In both instances, Dolcy forms the minor component of the map unit.

Because of its sandy nature and associated lower water holding capacity, this soil has some limitation for dryland agriculture. Under irrigation, the relatively shallow depth to till could present a seepage problem, thus lowering the desirability of this soil for irrigated crop production.

Duchess series (map symbol Dh)

Detailed information in Appendix
Extent - 8015 ha (1.31% of total)
Classification - Brown Solodized Solonetz
Usual surface texture - silt loam
Major associated series - Gem, Wardlow, Hemaruka, Halliday

Parent material - fine loamy fluvial or lacustrine veneer over till
Associated landform - undulating and low-relief hummocky
Slope range - 2-9%
Drainage - moderately well drained
Agricultural capability - 4 d
Irrigation rating - poor
Grazing carrying capacity - 16-24 ha/AUY

Duchess soil is characterized by a solonetzic B horizon and occurrence of the underlying till at less than 1 m. The solonetzic B horizon has developed in a fine loamy fluvial or lacustrine material which forms a veneer above the till. Surface horizons are usually silt loam and slightly acid to neutral. Moderately alkaline conditions prevail in the B and C horizons which generally have a clay loam texture. Lime may occur in the overlay material but is always present in the underlying till, which can be at quite variable depths. Often a sandy or gravelly contact separates the upper material from the till below. A detailed description of a Duchess soil is included in the Appendix, and it is pictured in Fig. 20.

Figure 20. Soil profile of the Duchess series.

This soil is found in transition areas between till and fluvial or lacustrine areas, usually in an equivalent part of the soil landscape to that occupied by Cranford, as illustrated in Figure 18. With Duchess, however, the other soils are usually Solonetzic. Although this soil is fairly widespread in the county, there are few areas of predominantly Duchess soil. Most of those mapped were found in the transition areas between Kininvie Plain and Matzhiwin or Chin Plain, primarily in the southern half of the county. Along the northern edge of Chin Plain, where it merges into Kininvie Plain, Duchess was mapped in association with such soils as Wardlow, Cranford, Gem, Timko, Halliday, and Cecil, usually as the minor component of the map unit. Similar combinations were encountered along the eastern edge of Matzhiwin Plain. Fairly extensive areas of Duchess soil were mapped along the numerous erosion channels stretching southward from the badlands of Dinosaur Provincial Park. These variants generally have a IIC horizon of soft rock material.

Duchess soils have a low rating for cultivated agriculture, particularly under irrigation. Not only do they have a low irrigation rating because of their Solonetzic characteristics and an associated salinity hazard, but seepage could be a further problem, especially where coarse fluvial deposits occur above the till.

Dishpan series (map symbol Dp)

Detailed information in Appendix
Extent - 3885 ha (0.63% of total area)
Classification - Rego Gleysol, saline phase
Usual surface texture - silt loam
Major associated series - several
Parent material - fine loamy fluvial or lacustrine
Associated landform - level and depressional
Slope range - 0-2%
Drainage - poorly drained
Agricultural capability - 6 m
Irrigation rating - non-irrigable
Grazing carrying capacity - 19-32 ha/AUY

Dishpan soils can be recognized by the visible salt flecks, particularly in the drier portions of the profile. Only the surface horizon has any distinguishable structure, and that is often very weak. Textures range from silt loams in the upper profile to much finer textures in the lower profile. These texture differences are usually the only obvious basis on which to make horizon separations, as olive colors and massive structures are common throughout the C horizon. Moderately alkaline pH values are characteristic of this soil, as are the strongly saline conditions.

In this county, Dishpan soils occur mainly within Matzhiwin and Chin plains where fine loamy and coarse fluvial deposits occur. This soil rarely occurs by itself; it is most often a minor component of the map unit, primarily in association with Chin soils (Fig. 21). The soil, particularly the subsoil, is almost always wet because of the low and poorly drained position it occupies in the landscape. A high water table is common. Apparently irrigation has contributed significantly to the occurrence of this soil in the County of Newell, as Dishpan soils occur more frequently in

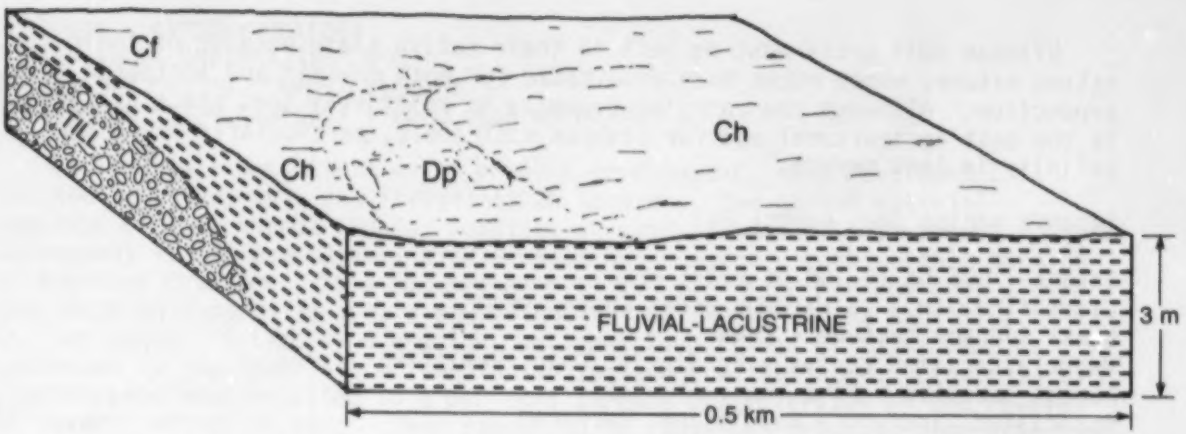



Figure 21. Cross-sectional diagram of a typical toposequence associated with a Dishpan-Chin complex.

irrigated areas than in non-irrigated. In many areas characterized by groundwater discharge and severe salinization, the Dishpan soil becomes the dominant component of the map unit. Salinity may become so severe (Fig. 22) that only the most salt-tolerant grass species can survive. It is not uncommon to see a surface salt crust in Dishpan soil areas, particularly during drier periods of the summer.

Figure 22. A Dishpan soil area. Note the saline areas with no vegetation.

Dishpan soil areas must be left in their native state because of their saline nature, which makes them unsuitable for both dryland and irrigated crop production. Although the carrying capacity is relatively low, stock grazing is the best agricultural use for Dishpan soil areas, particularly where the salinity is less severe.

Expanse series (map symbol Ep)

Extent - 605 ha (0.10% of total area)
Classification - Calcareous Brown Chernozemic
Usual surface texture - loam
Major associated series - Verdigris, Chin, Ramillies
Parent material - fine loamy fluvial
Associated landform - undulating, terraced
Slope range - 2-9%
Drainage - well drained
Agricultural capability - 4 m
Irrigation rating - fair
Grazing carrying capacity - 16-24 ha/AUY

Expanse soil is distinguished from other Chernozemic soils on a similar parent material by a weakly developed and often thin B horizon containing lime. A surface texture of loam grades into a loam B horizon below which textures are generally loam to silt loam. A weakly developed prismatic structure in the B horizon breaks down rather easily because of the lime present. Alkaline pH values below the A horizon further characterize this soil.

The limited area of Expanse soil is confined to the valley of Bow River downstream from Bassano Dam. Expanse soils have been mapped in association with the Chin series on higher benches of the valley where soils are better developed. On lower benches of more recent deposition, Expanse has been mapped with the Verdigris series. In some locations, the Ramillies series was found to be closely associated. No consistent trend was evident in these combinations as Expanse soils occurred both as the major and minor component of the map unit.

Although Expanse soils are rated as Class 4 for agriculture, they are less desirable than other Class 4 soils because of the lime carbonate in the surface horizon. Stream channels often dissect these areas, increasing the difficulty of cultivation and decreasing field areas to an impractical size.

Etzikom series (map symbol Ez)

Extent - 475 ha (0.08% of total area)
Classification - Orthic Regosol
Usual surface texture - gravelly sand
Major associated series - Antelope
Parent material - sandy skeletal fluvial
Associated landform - undulating and ridged
Slope range - 2-15%

Drainage - rapidly drained
Agricultural capability - 6 m
Irrigation rating - non-irrigable
Grazing carrying capacity - more than 49 ha/AUY

Etzikon soil has little or no profile development. Any development is limited to a very thin and indistinct Ah horizon. The parent material consists of ice-contact fluvial deposits of sandy to gravelly texture. Subsequent to its deposition, wind erosion has removed a considerable portion of the sand fraction. This has happened in the one major Etzikom area within the rough Rolling Hills area a few kilometres northwest of the hamlet of Rolling Hills. Active wind erosion continues in portions of this area, as evidenced by the inability of vegetation to become established. Centuries of wind erosion have resulted in a deflated surface characterized by the removal of several metres of sand. This reworking by winds has produced some dune formation, hence the inclusion of the Antelope series with Etzikom. This area is probably a partial source of sand for the dunes formed to the southwest. A few isolated small areas of Etzikom soil occur elsewhere in the county.

Because of its coarse texture and associated low water-holding capacity, coupled with the rough topography, Etzikom soil has no potential for cultivated agriculture. It has a very low grazing capacity; the grass cover, when present, is sparse and can easily be destroyed by overgrazing. This and adjoining areas are a favorite grazing range for antelope.

Foremost series (map symbol Fm)

Detailed information in Appendix
Extent - 7040 ha (1.15% of total area)
Classification - Orthic Brown Chernozemic
Usual surface texture - loam
Major associated series - Maleb, Cecil, Antonio, Bingville, Gopher
Parent material - coarse loamy to fine loamy till
Associated landform - undulating and hummocky
Slope range - 2-30%
Drainage - well drained
Agricultural capability - 4 m
Irrigation rating - good
Grazing carrying capacity - 16-19 ha/AUY

Like all Orthic Chernozemic soils, Foremost has well developed A, B, and C horizons. Development has taken place in a water-sorted till deposit from which much of the clay has been removed, so that loam is prevalent throughout the profile. Brownish colors common to all horizons grade to paler browns in the C horizon primarily due to the presence of lime. This lime gives the C horizon a moderately to mildly alkaline reaction. Above the C, the B horizon is mildly alkaline and the A horizon neutral. Soil structure is most obvious in the B horizon where a prismatic structure has developed. Variations in texture from that described are fairly common; they range from profiles with a high silt content to those with more sand.

On the east side of Lake Newell in Rolling Hills, fairly extensive areas of water-sorted till occur on which Foremost soils have developed. Associated glaciofluvial deposits result in map units having Antonio and Gopher soils as major or minor components. Another fairly extensive Foremost soil area is located in the southern part of Crawling Valley Upland on the western side of the spillway. In that area Foremost is closely associated with materials deposited from spillway action. Thus, Foremost soil is associated with Antonio or Bingville where fluvial materials are prevalent and Maleb or Cecil where till soils are dominant. Less extensive areas of Foremost occur in the western portion of Kininvie Plain, primarily in association with the Maleb and Cecil series. Although Foremost soils occur on a wide range of topographies and slopes, the most common landform is undulating to gently rolling with slopes around 5%.

Foremost soil areas have a relatively high rating for both dryland and irrigated agriculture. However, areas in which the coarse textured member occurs are less desirable for dryland agriculture because of the reduced water-holding capacity.

Flagstaff series (map symbol Fs)

Extent - 8420 ha (1.37% of total area)
Classification - Solonetzic Dark Brown Chernozemic
Usual surface texture - loam
Major associated series - Hughendon, Brownfield
Parent material - fine loamy till
Associated landform - undulating and hummocky
Slope range - 2-15%
Drainage - well drained
Agricultural capability - 3 m
Irrigation rating - good
Grazing carrying capacity - 10-12 ha/AUY

The Flagstaff series has profile characteristics similar to the Cecil profile described in the Appendix. The most significant difference is that Flagstaff is a Dark Brown soil and therefore the Ah is dark brown whereas the Cecil Ah is brown. Usually, the Flagstaff soil has a few more centimetres of Ah than the Cecil soil. However, the B and all subsequent horizons in the two soils are comparable, although in Flagstaff they tend to be slightly thicker.

In the County of Newell, Flagstaff soils are found only within the Dark Brown soil zone. This includes the western part of Crawling Valley Upland, as well as a small portion of Kininvie Plain west of Bassano. Flagstaff is the dominant soil in the western portion of Crawling Valley Upland, where it occurs most frequently on gently rolling or rougher topography. There, it is most often associated with the Hughendon series (the Orthic Dark Brown Chernozemic on till), usually as the major component. In areas where the soils have solonetzic characteristics, Flagstaff is found in association with Brownfield and Halkirk, usually in upper slope positions. This is a similar relationship to that shown in Figure 16 for the Cecil-Halliday-Hemaruka sequence, with Flagstaff occupying a similar landscape position to that of

Cecil. Toward the southern extreme of Crawling Valley Upland where slopes are less severe, Flagstaff is occasionally found in association with the Whitney series in lower-lying areas that have a veneer of fluvial or lacustrine material. A similar association occurs in that portion of Kininvie Plain lying directly west of Bassano.

Occurring within the Dark Brown soil zone with its better precipitation, Flagstaff soils have a higher potential for dryland agriculture than most soils in the county. However, many Flagstaff soil areas are being used for grazing, primarily because of the rough topography. Also because of topography, Flagstaff areas in this county have little irrigation potential even though the soil has a high irrigation rating.

Gem series (map symbol Ge)

Extent - 6520 ha (1.06% of total area)
Classification - Brown Solod
Usual surface texture - silt loam
Major associated series - Duchess, Karlsbad
Parent material - fluvial or lacustrine veneer over till
Associated landform - undulating and low-relief hummocky
Slope range - 2-9%
Drainage - moderately well drained
Agricultural capability - 4 d
Irrigation rating - poor
Grazing carrying capacity - 14-19 ha/AUY

Gem soil is a Solod in which profile development has taken place in a fluvial or lacustrine material overlying till. The depth to till averages 50-75 cm, but never exceeds 1 m. This profile has about 8 cm of brown Ah which grades to a brownish gray Ae horizon about 6 cm thick in which a platy structure has developed. Both horizons are very friable silt loam and generally are slightly acid. The transitional AB horizon is relatively thin dark brown silt loam to silty clay loam with a friable subangular blocky structure and usually a neutral pH. The Bnt horizon below has a columnar structure which breaks into firm subangular blocky aggregates. This horizon, about 15 cm thick, is also dark brown but gradually changes to yellowish brown near the 40-cm depth where a lime horizon usually occurs. Mildly alkaline conditions prevail in the B horizon which has a silty clay loam texture. The lime horizon, which is moderately alkaline, has a silt loam texture. Sulfate salts are sometimes present in the C horizon above the till, which is similar to the till on which many soils in the county have developed. It is not unusual to find a layer of coarse fluvial material directly above the till, separating it from the overlying fluvial or lacustrine materials.

This soil has profile characteristics similar to those of the Karlsbad series. The one important difference is that Karlsbad does not have underlying till within the 1-m depth, but always deeper. Thus these two soils commonly occur in close association. Many Gem soils are found in transition areas between the fluvial to lacustrine materials of Matzhiwin Plain and the till areas of Kininvie Plain. In these areas, Gem is found primarily with

Duchess and to a lesser extent with Halliday and Hemaruka. A large Gem area in association with Duchess soils occurs on the landscape dissected by deep erosion channels which stretch southward from Dinosaur Provincial Park. Because Gem has developed on a veneer overlying till, the surface topographic features usually reflect the surface characteristics of the underlying till. Consequently, surface features in a Gem area are characterized by a combination of fairly smooth slopes and a subdued and low-relief hummocky landform.

Primarily because of the limitations associated with their solonetzic profile characteristics and saline subsoil, Gem soils have a marginal potential for irrigation. The underlying till presents a further limitation, especially when separated from the fluvial or lacustrine material by a coarse fluvial layer which tends to promote lateral water movement and saline seep. For dryland agriculture, the solonetzic B horizon is not as much of a limitation as is the scarcity of moisture in the area.

Gopher series (map symbol Gp)

Extent - 3765 ha (0.61% of total area)
Classification - Brown Solodized Solonetz
Usual surface texture - sandy loam
Major associated series - Antonio, Bingville, Hemaruka, Cavendish
Parent material - coarse loamy fluvial veneer over till
Associated landform - undulating and hummocky
Slope range - 2-15%
Drainage - rapidly to well drained
Agricultural capability - 4 m
Irrigation rating - non-irrigable
Grazing carrying capacity - 16-19 ha/AUY

The Gopher series is another of several soils in the county that have a two-tiered parent material, in this case a coarse loamy fluvial material overlying till. It is classified as a Solodized Solonetz with the solonetzic B horizon developed in the underlying till (IIBnt), which can occur at variable depths up to 1 m. A brown to grayish brown Ah horizon ranges in thickness from 8 to 20 cm and grades to a pale brown Ahe horizon about 15 cm thick. Below this is a grayish brown Ae horizon a few centimetres thick. Sandy loam textures in the upper part of the profile grade to a loamy sand in the Ae horizon. All horizons above the IIBnt have a granular structure and are quite friable, as well as slightly acid. There is an abrupt break to the IIBnt horizon formed in till, at about the 50-cm depth. This horizon has strong columnar round-tops which break with some difficulty to a subangular blocky structure. Dark brown colors in the B horizon change to brown and then to pale brown in the lime horizon, at about 65 cm deep. With increased depth, structure becomes less pronounced until it is not discernible in the lime horizon. A clay loam texture in the Bnt gradually gives way to a loam to clay loam in the unaltered till (IIC horizon). Mildly to moderately alkaline conditions further characterize these lower horizons, as well as variable amounts of salts. A Gopher profile is pictured in Fig. 23.

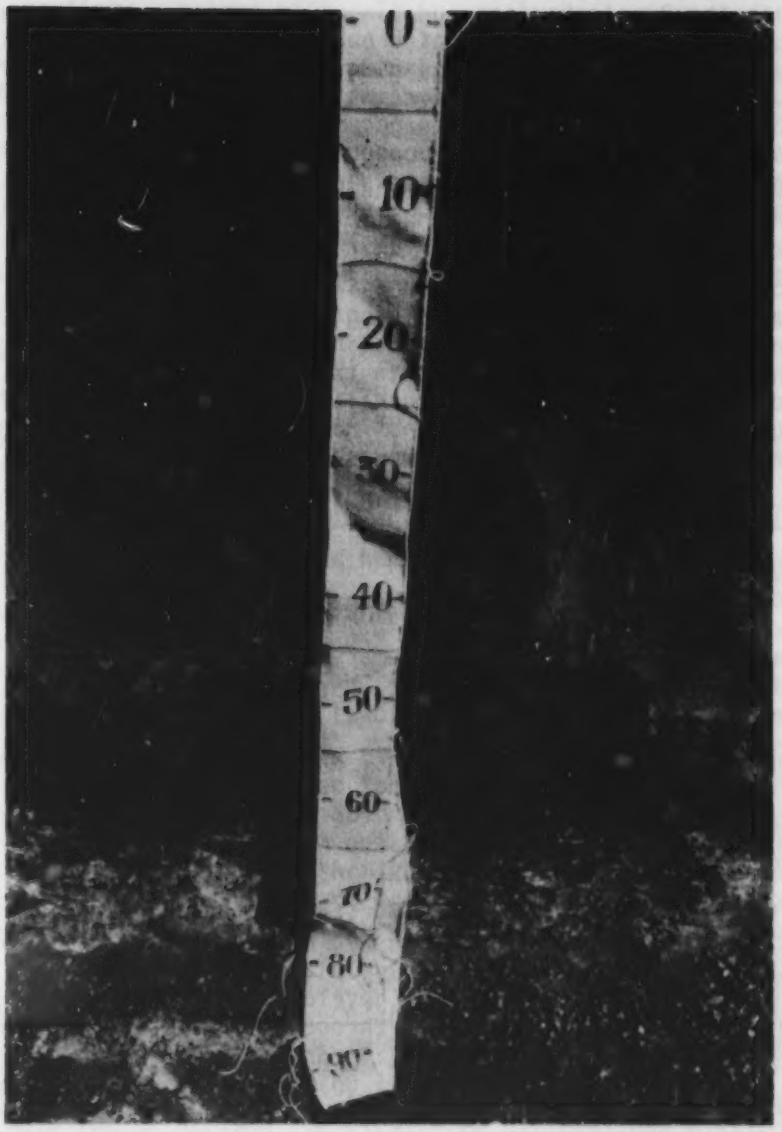



Figure 23. Soil profile of the Gopher series.

This soil is not too widespread in the county. It is mainly concentrated in parts of Matzhiwin Plain where the underlying till is close to the surface and covered by a veneer of fluvial material. Such an area occurs at the northern extreme of Matzhiwin Plain where associated soils are mainly Cavendish and Antonio. In an area north of Millicent, Gopher series is associated with the Purple Springs and Bingville series. Small areas in the vicinity of San Francisco Lake west of Brooks have Gopher soils associated with Hemaruka as well as Cavendish and Bingville. Along the eastern side of Lake Newell on ridgelike landforms, Foremost and Antonio are the main associated soils. A similar situation occurs in Kininvie Plain several kilometres northeast of Tilley where Gopher is associated with Antonio and Cecil. Except for the area east of Lake Newell, most Gopher soils present a subdued hummocky landform reflecting the surface features of the underlying till.

Gopher soils are considered to be non-irrigable, mainly because of the highly permeable fluvial material overlying the less permeable till. Such a situation tends to promote seepage and salinity problems, especially when solonetzic characteristics are present in the underlying material. For dryland agriculture the soil has a marginal capability because of the low water-holding capacity of the A horizon. However, the B horizon may act as a barrier preventing complete loss of downward-percolating moisture.

Gleddies series (map symbol Gs)

Extent - 2710 ha (0.44% of total area)
Classification - Rego Gleysol, saline phase
Usual surface texture - silty clay
Major associated series - Sterling, Rosemary
Parent material - fine clayey lacustrine
Associated landform - level and depressional
Slope range - 0-2%
Drainage - poorly drained
Agricultural capability - 6 n
Irrigation rating - non-irrigable
Grazing carrying capacity - 19-32 ha/AUY

Gleddies soil can be distinguished by its high salinity which limits vegetative cover to salt-tolerant grasses such as foxtail, and in more extreme situations samphire, Salicornia sp. (color plate, Figure 32). This soil lacks profile development except for a weakly developed A horizon; dull colors indicative of poor drainage are evident throughout. The weakly developed Ah horizon is usually very thin and dark olive gray. Below this, no distinct horizonation can be observed. The fairly uniform olive gray continues well into the profile, as does the silty clay texture. Sulfate salts and carbonates result in strongly saline and moderately alkaline conditions.

In terms of extent, this soil is not widespread in the county. It is confined to low poorly drained areas of lacustrine deposits. Its occurrence is mainly limited to saline areas within Matzhiwin Plain where lacustrine soils with solonetzic characteristics are dominant. Such an area occurs northwest of Rosemary where the Gleddies series is associated with the

Sterling and Rosemary series and to a lesser extent the Scotfield series. The large elongated natural depression about 8 km north of Brooks is a good example of the landform environment often associated with Gleddies soil. This area (Figure 32) has a uniformly high salt content as indicated by the overall cover of samphire. Numerous relatively small depressional areas within Kininvie Plain, in the eastern part of the county, have been infilled with lacustrine material. Because they are also saline, these small areas have been identified as Gleddies. However, since most of them are too small to show at the 1:63 000 scale, they have been included as a minor component of the map unit dominated by Halliday and Hemaruka series.

Because of its saline and poorly drained features, Gleddies soil cannot be used for any kind of cultivated agriculture. Even for grazing it has limited use depending on the extent of salinity. Usually, within each Gleddies area there are some less saline areas that can better support some grazing activity.

Halliday series (map symbol Hd)

Detailed information in Appendix
Extent - 70 135 ha (11.44% of total area)
Classification - Brown Solod
Usual surface texture - loam
Major associated series - Hemaruka, Ronalaine, Cecil
Parent material - fine loamy till
Associated landform - undulating and hummocky
Slope range - 2-15%
Drainage - moderately well drained
Agricultural capability - 4 d
Irrigation rating - poor
Grazing carrying capacity - 14-19 ha/AUY

Halliday soils can be recognized by a remnant transitional AB horizon which often retains the round-topped form, but not the strong secondary structure, of the former Solodized Solonetz from which they have evolved. This friable AB horizon breaks down quite easily into subangular blocky peds. The transition to the columnar Bnt horizon is gradual, both in color and texture. Clay loam textures and dark brown colors are normal characteristics of the Halliday B horizon. Horizons above are brown to grayish brown. The structural characteristics of the Bnt horizon gradually become less obvious through the BC horizon, disappearing entirely in the Cca horizon at about 45-55 cm deep. Salts are usually present at these lower depths. Mildly alkaline pH values in the B horizon increase to moderately alkaline in the lime horizon. Above, in the A horizon, slightly acid conditions prevail. The profile described in the Appendix differs somewhat from other Halliday profiles because the AB horizon can usually be divided into distinct Ae and AB horizons. Another difference is the 71-cm depth at which the lime occurs; this is unusually deep. Perhaps the most notable difference is the loam texture of the Bnt horizon, which is usually clay loam.

Halliday, the most frequently occurring soil in the County of Newell, is found primarily on Kininvie Plain in association with the Hemaruka, Cecil, Ronalaine, or Maleb series. As illustrated in Figure 16, Halliday usually occupies the lower-slope topographic position, either as the major or minor

component of the map unit. Northeast of Brooks in Kininvie Plain where soft rock materials are closer to the surface (see Figure 9), Halliday is often associated with Steveville soil. In Kininvie Plain, Halliday soils are most often found on undulating topography whereas in Crawling Valley Upland they generally occur on gently rolling landforms. On the Upland, however, Halliday soil is seldom the major map unit component, but forms the minor component with Cecil and Maleb. Also in Crawling Valley Upland, several areas of a thin phase of the Halliday series were evident.

Suitability for both dryland and irrigated agricultural uses is influenced to some degree by the solonetzic character of this soil. Irrigation in particular is adversely affected, not only by the solonetzic structure but more importantly by the subsoil salts, which always have the potential to create surface salinity under irrigation. Under continued dryland farming, this soil tends to develop medium to strongly acid conditions in the A horizon, often to the point where crop growth is affected. Because so few of the Halliday areas are being cultivated, it is doubtful whether this abnormality, known as "acid Solod", has become a major problem in the County of Newell.

Halkirk series (map symbol Hk)

Extent - 690 ha (0.11% of total area)
Classification - Dark Brown Solodized Solonetz
Usual surface texture - loam
Major associated soils - Brownfield, Flagstaff
Parent material - fine loamy till
Associated landform - undulating and hummocky
Slope range - 2-15%
Drainage - moderately well drained
Agricultural capability - 3 d
Irrigation rating - poor
Grazing carrying capacity - 14-19 ha/AUY

Halkirk soils can be recognized by the strongly developed columnar round-topped structure of the B horizon. The dark brown Ah horizon, which generally has a loose granular structure, changes to a grayish brown Ae horizon above the Bnt. These upper horizons generally have a loam texture and are neutral to slightly acid. There is an abrupt change to the Bnt horizon at about 16-18 cm below the surface. This horizon is dark brown clay loam to clay, with a hard subangular blocky structure that is very resistant to further breakdown. Because plant roots can penetrate the Bnt horizon only by a tortuous and zigzag route along and between the hard angular blocks, they usually have a flattened appearance. Structural development of the B horizon gradually becomes less apparent with depth until it is very weak in the Cca horizon, at or near 36-40 cm deep. Mildly alkaline conditions in the B horizon change to moderately alkaline in the lime horizon, where clay loam textures prevail and salts are common.

Halkirk soil has characteristics similar to those of the Hemaruka profile described in the Appendix. Differences are mainly in the color and thickness of the A horizon; Halkirk has a darker brown and thicker A horizon than Hemaruka soil. Halkirk also occupies a similar position to that of Hemaruka in the topographic sequence, as illustrated in Figure 16.

Occurrences of Halkirk soils in the county are limited to a small area in the northern portion of Crawling Valley Upland within the Dark Brown soil zone, where Solonetzic soils occur. Soils associated with Halkirk are mainly Brownfield and Flaystaff, with Halkirk as the minor component of the map unit. In this area, Halkirk is generally found on undulating topography. Up to 20% eroded pits are usually associated with Solonetzic soils.

Halkirk soils have a relatively low irrigation rating because of the solonetzic B horizon and the possibility of salinization. Although not as limiting, these characteristics also affect its use for dryland agriculture, especially where eroded pits are numerous.

Hughendon series (map symbol Hn)

Extent - 6920 ha (1.13% of total area)
Classification - Orthic Dark Brown Chernozemic
Usual surface texture - loam
Major associated series - Flagstaff, Brownfield, Whitney
Parent material - fine loamy till
Associated landform - undulating and hummocky
Slope range - 2-30%
Drainage - well drained
Agricultural capability - 3 m
Irrigation rating - good
Grazing carrying capacity - 10-12 ha/AUY

Hughendon soils have a dark brown Ah horizon 10-15 cm thick. It is a very friable loam with a slightly acid to neutral reaction. The B horizon, usually about 15-20 cm thick, is dark grayish brown and has a fairly distinct prismatic structure which breaks easily to subangular blocky. The loam to clay loam texture continues into the Cca horizon at about 35 cm below the surface. The neutral to mildly alkaline reaction of the B horizon changes abruptly to moderately alkaline in the lime horizon. Pale brown colors are common in this horizon which is generally very weak blocky to massive. With increasing depth the lime content and hence the pH value decrease. At these lower depths the texture continues to be loam to clay loam in a pale brown till. Except for a darker and thicker Ah horizon, the Hughendon soil is very similar to the Brown Chernozemic Maleb series described in the Appendix.

Many of the dark brown soils in Crawling Valley Upland belong to this series. In the northern part of the upland where the topography is rougher and soils tend to be Solonetzic, the Hughendon series is mapped as a minor map unit component with the Flagstaff and Brownfield series. The dark brown portion of the southern upland area has less severe slopes as well as a dominance of Chernozemic soils. Many of the lower areas also have a veneer of fluvial or lacustrine material deposited over the till. As a result, Hughendon has been mapped as the dominant member of the map unit primarily in combination with Flagstaff and Whitney.

Hughendon soils are among the best in the county for both irrigated and dryland agriculture. Although it is not a severe problem in this county, some Hughendon areas may be stony, which of course results in a less desirable soil for agriculture.

Helmsdale series (map symbol Hs)

Extent - 240 ha (0.04% of total area)
Classification - Rego Brown Chernozemic
Usual surface texture - loam
Major associated series - Maleb
Parent material - fine loamy till
Associated landform - undulating and hummocky
Slope range - 2-30%
Drainage - well drained
Agricultural capability - 5 mf
Irrigation rating - fair
Grazing carrying capacity - 19-24 ha/AUY

A significant characteristic of Helmsdale soil is its lack of a B horizon. It has a grayish brown Ah horizon about 5-10 cm thick with a very friable granular structure and a neutral reaction. Below this, the Cca horizon is light gray and weak subangular blocky to massive. Textures are usually clay loam, which continue well into the lower horizons. A moderately alkaline reaction gradually decreases to mildly alkaline at about 40-50 cm where the concentration of lime decreases.

Few Helmsdale soils occur in the county. They were mapped only in Crawling Valley Upland in association with the Maleb series and always as a minor component of the map unit. Occurrences were mainly on rough topography where this soil is generally found on the crowns of steeper knolls. It is not uncommon to find stones in areas where the Helmsdale soil has been mapped.

Proximity of lime to the surface is significant to the lower ratings given this soil for both dryland and irrigated agriculture. However, in the County of Newell, all areas of Helmsdale soils would be non-irrigable because of the associated rough topography.

Hemaruka series (map symbol Hu)

Detailed information in Appendix
Extent - 59 565 ha (9.72% of total area)
Classification - Brown Solodized Solonetz
Usual surface texture - loam
Major associated series - Halliday, Steveville, Cecil, Ronalaine
Parent material - fine loamy till
Associated landform - undulating and hummocky
Slope range - 2-15%
Drainage - moderately well drained
Agricultural capability - 4 d
Irrigation rating - poor
Grazing carrying capacity - 16-24 ha/AUY

The main distinguishing feature of Hemaruka soil is the hard columnar round-topped structure of the Bnt horizon (Fig. 24), which is very resistant to breakdown. This horizon has a clay loam to clay texture, a dark grayish brown color, and a neutral to mildly alkaline reaction. Above, the A horizon

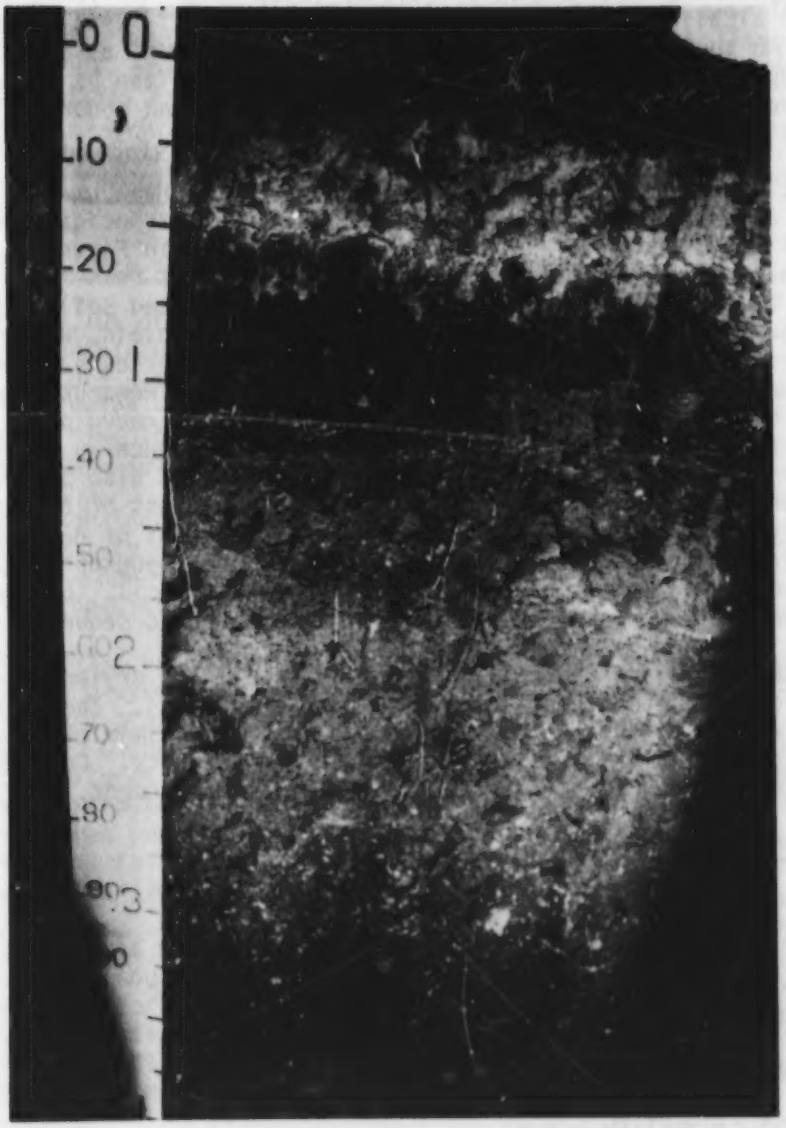



Figure 24. Soil profile of the Hemaruka series.

is divided into an Ah about 8 cm thick and an Ae about 3 cm thick. Both horizons have a loam texture and a neutral to slightly acid reaction. The lower B horizon is weaker structured than the Bnt and gradually increases in alkalinity as it approaches the Cca horizon at about 35 cm below the surface. Lighter colors are also characteristic of these lower horizons, as are moderately alkaline pH values and clay loam textures. Usually, Hemaruka has a thicker Ah than that of the described profile, as well as a lime horizon at greater depths. Salts are often present in the C horizon as well. The sandy loam Ck3 horizon occurring at the 78-cm depth is not an abnormal feature; such lenses are frequently present in till materials.

Almost 10% of the county area has been mapped as Hemaruka soils. These are found almost exclusively in Kininvie Plain where associated soils are mostly Halliday, Cecil, or Ronalaine, as illustrated in Figure 16. In the northern part of the eastern Kininvie Plain where soft rock materials are closer to the surface, Steveville is the main associated soil. This is illustrated in Figure 30. At the edges of this till plain, where some fluvial or lacustrine deposition has occurred, the Hemaruka series has been mapped in association with the Duchess and Timko series. These Hemaruka areas are generally of low relief with undulating topography. Eroded pits in varying amounts are a common feature, and when cultivated produce an uneven crop pattern (color plate, Figure 33). Slight stoniness is also present in most Hemaruka areas. However, one area about 10 km southeast of Bassano is excessively stony and badly eroded. Very limited areas of Hemaruka occur in Crawling Valley Upland, primarily on gently rolling topography, as the minor map unit component in association with Halliday and Cecil. Commonly Hemaruka is found in the lower-slope position of the topographic sequence.

Hemaruka soils are generally marginally arable for dryland and irrigated agriculture because of their solonetzic characteristics. The more desirable are those with a thicker Ah horizon coupled with a minimum of eroded pits. Under irrigation, there is always the threat of salinity. Consequently, Hemaruka soil areas require greater attention to management.

Islands series (map symbol In)

Extent - 650 ha (0.11% of total area)
Classification - Rego Gleysol
Usual surface texture - loamy sand
Major associated series - Cavendish, Yarnley, Vendisant
Parent material - sandy fluvial
Associated landform - level and depressional
Slope range - 0-2%
Drainage - poorly drained
Agricultural capability - 5 w
Irrigation rating - non-irrigable
Grazing carrying capacity - 10-12 ha/AUY

Islands soil is characterized by its coarse texture and poorly drained features. A dark grayish brown Ah horizon about 10 cm thick merges into grayish, structureless subsoil in which some mottles usually appear. Low concentrations of lime are often present in the lower subsoil.

In this county, Islands soils were found in poorly drained areas associated with sandy eolian deposits. Hence, Islands was mapped in association with Cavendish and Vendisant and to some extent Rolling Hills, in the sandy areas north of Rolling Hills hamlet. About 12 km north of Rosemary, Islands was mapped in association with the Yarnley series. In both locations, Islands formed the minor map unit component. Islands soil was also found in the two elongated depressions located about 6 km northeast of Rolling Hills. These two depressions, which generally form the upper end of Twelve Mile Coulee, both lie within a large sandy area.

Because of its poorly drained characteristics and coarse texture, Islands soil is not suited for either dryland or irrigated agriculture. However, it has a relatively high grazing carrying capacity.

Illingworth series (map symbol Iw)

Extent - 605 ha (0.10% of total area)
Classification - Orthic Gleysol
Usual surface texture - silt loam
Major associated series - Chin, Bingville
Parent material - fine loamy fluvial or lacustrine
Associated landform - level and depressional
Slope range - 0-2%
Drainage - poorly drained
Agricultural capability - 5 w
Irrigation rating - non-irrigable
Grazing carrying capacity - 8-10 ha/AUY

Illingworth soils, because they are found in poorly drained landscape positions, display gleyed colors throughout the profile. A surface horizon 2-3 cm thick is dark grayish brown silt loam. A Bg horizon about 15 cm thick has distinct gleyed colors in a mottled olive gray material. Silt loam to silty clay loam textures predominate in this horizon, which has a coarse subangular blocky structure. Colors are somewhat lighter in the Cg horizon where gleyed features persist and a massive structure is evident. A silty clay loam texture is fairly consistent in the C horizon, the lower portion of which often has a low lime content.

This soil, which is relatively insignificant in the County of Newell, occurs mostly at the southern extreme of the Crawling Valley spillway, which forms the headwaters for Matzhiwin Creek. In this poorly drained and ill-defined valley portion of Matzhiwin Creek, Illingworth soils have been mapped primarily with Bingville soils and to a lesser extent Pemukan soils. Small areas of Illingworth occur in the southern part of Chin Plain south of Scandia.

The poorly drained features of the Illingworth soil make it unsuitable for either irrigated or arable dryland agriculture. It is, however, well suited for grazing and has a relatively high carrying capacity.

Karlsbad series (map symbol Kd)

Detailed information in Appendix
Extent - 17 010 ha (2.78% of total area)
Classification - Brown Solod
Usual surface texture - silt loam
Major associated series - Wardlow, Tilley, Gem, Rosemary
Parent material - fine loamy fluvial or lacustrine
Associated landform - undulating and low hummocky
Slope range - 2-9%
Drainage - moderately well drained
Agricultural capability - 4 d
Irrigation rating - fair
Grazing carrying capacity - 14-19 ha/AUY

Karlsbad soils are recognizable from their dark brown columnar Btnj horizon overlain by an AB horizon a few centimetres thick. Above this the Ah and Ae horizons are brownish loam to silt loam. Below the Btnj, colors gradually become lighter, especially in the horizon of lime accumulation. The Btnj and lower horizons are fine textured and alkaline. Above the Btnj, slightly acid conditions prevail. The profile described in the Appendix has some atypical features. The Ah horizon is unusually thin and the B horizon has a Ca:Na ratio slightly greater than 10.

Karlsbad soils occur almost entirely within Matzhiwin Plain, especially toward its edges. Fairly extensive areas of this soil are found southeast of the village of Rosemary, where the main associated soils are Tilley and Wardlow. In this vicinity, especially where soils tend to be somewhat finer textured, the Karlsbad series is associated with the Rosemary series. Another concentration of Karlsbad soils occurs in the Tilley area, where Wardlow and Tilley form the main associated soils. At the edges of Matzhiwin Plain east of Tilley where till is often at depths of less than 1 m, Karlsbad is associated with the Gem and Halliday series. In all these areas Karlsbad occurs as either the major or the minor map unit component. Surprisingly, very little Karlsbad soil occurs in Chin Plain.

An area of eroded Karlsbad soils was mapped along the eastern side of the county, directly east of Tilley. The soils were in most respects similar to the normal Karlsbad soil except that they had little or no Ah horizon. It was assumed that the topsoil had been removed by wind erosion several years before, probably as a result of cultivation and inadequate erosion controls. In any case, the B horizon now forms the surface horizon over most of this area.

Many areas of Karlsbad soil are being successfully irrigated in the County of Newell. However, the solonetzic B horizon and possible subsoil salts present a hazard, so that careful management is required to prevent salinization and ensure adequate returns. These profile characteristics are less limiting under dryland agriculture.

Kitsim series (map symbol Km)

Extent - 5025 ha (0.82% of total area)
Classification - Rego Gleysol, saline phase
Usual surface texture - loam
Major associated series - Hemaruka, Halliday
Parent material - fine loamy till
Associated landform - depressional
Slope range - 0-0.5%
Drainage - poorly drained
Agricultural capability - 6 n
Irrigation rating - non-irrigable
Grazing carrying capacity - more than 49 ha/AUY

Kitsim soil usually has little or no A horizon above the fine textured and strongly gleyed upper C horizon. With increased depth, there is often a decrease in clay content coupled with an increase in alkalinity from mildly to moderately alkaline, mainly because of the saline character of this soil.

In the County of Newell, Kitsim soils are found in the small flat depressional areas often associated with solonetzic till areas. Often these low areas, upon drying in mid- or late summer, develop a very thin surface layer of whitish material which appears to be an Ae. As drying continues a weak vertical cleavage appears, suggesting weak solonetzic development. Seldom do these areas have any vegetative cover, so they are easily recognizable as small irregular-shaped whitish depressions within uncultivated solonetzic till areas where blowout pits are common.

Within the county, all Kitsim soils are found in Kininvie Plain, mostly as areas too small to map. They have therefore been included as the minor map unit component primarily with Hemaruka and Halliday, the dominant soils within this plain. Northeast of Tilley, where soft rock materials are close to the surface, Kitsim has also been mapped with the Steveville series. Elsewhere, in locations where solonetzic development is less pronounced, Ronalaine forms one of the associated soils.

Kitsim soil areas should be avoided for all arable practices as they have no potential for either dryland or irrigated agriculture. They also have an extremely low grazing carrying capacity, but fortunately they comprise only 10-20% of any map unit.

Kangaroo series (map symbol Ko)

Extent - 40 ha (0.01% of total map area)
Classification - Orthic Brown Chernozemic
Usual surface texture - sandy loam
Major associated series - Maleb
Parent material - coarse loamy to sandy fluvial
Associated landform - ridged
Slope range - 15-30%
Drainage - rapidly drained
Agricultural capability - 5 m
Irrigation rating - poor
Grazing carrying capacity - 32-49 ha/AUY

Although Kangaroo soil is classified as Orthic Brown Chernozemic, its profile development is very weak. A grayish brown Ah horizon about 7 cm thick gradually merges into a darker brown Bm horizon, which has a very weak prismatic structure. This horizon, about 10 cm thick, has a sandy loam to loam texture. Below this, colors gradually change to pale brown in the C horizon with a corresponding increase in sand content. Loamy sand textures occur in the lower C horizon, in which both gravel and stone inclusions are common.

The Kangaroo soil was mapped in one area only: on the highest part of the prominent ridge about 4 km west of Millicent. This ridge is a local soft rock remnant capped with till and fluvial deposits, on which the Kangaroo profile has developed. Thus, the Kangaroo soil was included as the minor map unit component with the Maleb series. A few large boulders also occur in the fluvial material.

Because it occupies steeply sloping terrain, the Kangaroo soil area is unsuitable for both arable dryland and irrigated agriculture. Its only potential agricultural use is as native pasture, but it has a relatively low carrying capacity.

Kirkcaldy series (map symbol Kr)

Extent - 120 ha (0.02% of total area)
Classification - Dark Brown Solod
Usual surface texture - silt loam
Major associated series - Whitney
Parent material - fine loamy fluvial or lacustrine veneer over till
Associated landform - undulating and low hummocky
Slope range - 2-9%
Drainage - moderately well drained
Agricultural capability - 3 d
Irrigation rating - poor
Grazing carrying capacity - 12-16 ha/AUY

The Kirkcaldy series is similar to the Gem soil, its counterpart in the Brown soil zone. As with Gem, one important feature of the Kirkcaldy soil is the occurrence of till at 50-75 cm below the surface. Differences are mainly in the color and depth of the Ah horizon: darker brown and thicker in the Kirkcaldy soil. The Ah is 8-10 cm thick above the Ae and AB horizons present in all Solod soils. The columnar Bnt horizon with its silty clay loam or finer texture is considerably finer than horizons above or below. The pH values range from acidic in the A horizon to mildly alkaline in the B horizon and moderately alkaline in the C horizon.

Occurrence of Kirkcaldy soil is limited to the most westerly portion of the county lying north of the Trans-Canada Highway. There it is mainly a minor component with the Whitney soil and to a lesser extent the Lethbridge and Hughendon soils in areas with a veneer of fluvial or lacustrine material above the till.

Solonetzic characteristics combined with the two-tiered nature of the parent materials seriously lower the irrigation potential of Kirkcaldy soils. For dryland agriculture the effect of these characteristics is not as important.

Lethbridge series (map symbol Let)

Extent - 525 ha (0.09% of total area)
Classification - Orthic Dark Brown Chernozemic
Usual surface texture - silt loam
Major associated series - Whitney
Parent material - fine loamy fluvial or lacustrine
Associated landform - level, undulating, and low-relief hummocky
Slope range - 0.5-9%
Drainage - well drained
Agricultural capability - 3 m
Irrigation rating - good
Grazing carrying capacity - 9-11 ha/AUY

Lethbridge, like Chin, its Brown Chernozemic counterpart, can be recognized by its brownish solum and deep uniform parent material. Differences occur in the A horizon, which in the Lethbridge soil is both darker brown and thicker. Other major profile characteristics are similar to those of the Chin profile described in the Appendix of this report.

Sometime during the post-glacial past, portions of the southwestern part of the Crawling Valley Upland were inundated by waters that deposited fluvial or lacustrine materials. Thus, fine loamy materials of variable thickness were deposited over the lower portions of this till area. Subsequent soil formation produced a Lethbridge soil on deeper overlay deposits, Whitney on thinner deposits, and Hughendon where there was no overlay. Figure 18 illustrates a similar situation involving the counterparts of these three soils in the Brown soil zone.

Some Lethbridge soils were mapped in the valley of Bow River at the western edge of the map area. These were mainly on valley terraces where the associated soils were Chokio and Scollard. Toward the northern end of Crawling Valley, another Lethbridge area was mapped on a fluvial terrace, also in association with Scollard soils.

Because of their uniformity in texture and parent material, Lethbridge soils have a high irrigation rating. They also have a relatively high capability for both grazing and dryland farming.

Maleb series (map symbol Mb)

Detailed information in Appendix
Extent - 28 615 ha (4.6% of total area)
Classification - Orthic Brown Chernozemic
Usual surface texture - loam
Major associated series - Cecil, Ronalaine, Cranford, Halliday
Parent material - fine loamy till
Associated landform - undulating and hummocky
Slope range - 2-30%
Drainage - well drained
Agricultural capability - 4 m
Irrigation rating - good
Grazing carrying capacity - 14-19 ha/AUY

Maleb soils are characterized by brown colors, a friable structure, and a prominent lime horizon (Fig. 25). This Chernozemic profile has developed on a fine loamy till similar to the till that is prevalent in the Crawling Valley Upland. Acidic pH values in the A horizon increase to alkaline values below the B horizon. It should be noted that the described soil has a thinner than normal Ah horizon as well as an abnormally shallow depth to lime, which is usually encountered below the 25-cm depth. Salts may or may not be present in Maleb subsoils.

The most extensive areas of Maleb occur in Crawling Valley Upland, primarily on gently rolling topography. There, as illustrated in Figure 16, associated soils are mainly Cecil and to a lesser extent Halliday in areas where soils tend to be Solonetzic. On the more extreme hummocky terrain, where steeper slopes are common, Maleb soils have a thinner than normal Ah horizon. This is particularly true in an area on the eastern side of Crawling Valley north of Barkhausen Lake. Scattered areas of Maleb occur in Kininvie Plain, where associated soils mainly show the influence of the more saline till found there. Thus, the associated soils are Ronalaine and Halliday in addition to Cecil. Two such areas occur, one south and west of Lake Newell and the other south of Bassano. In many of the intermediate areas of mixed parent materials, between the till of Kininvie Plain and the fine loamy fluvial deposits of Matzhiwin Plain, Maleb has been mapped in association with the Cranford series. In all those areas, Maleb occurs as either the major or minor map unit component.

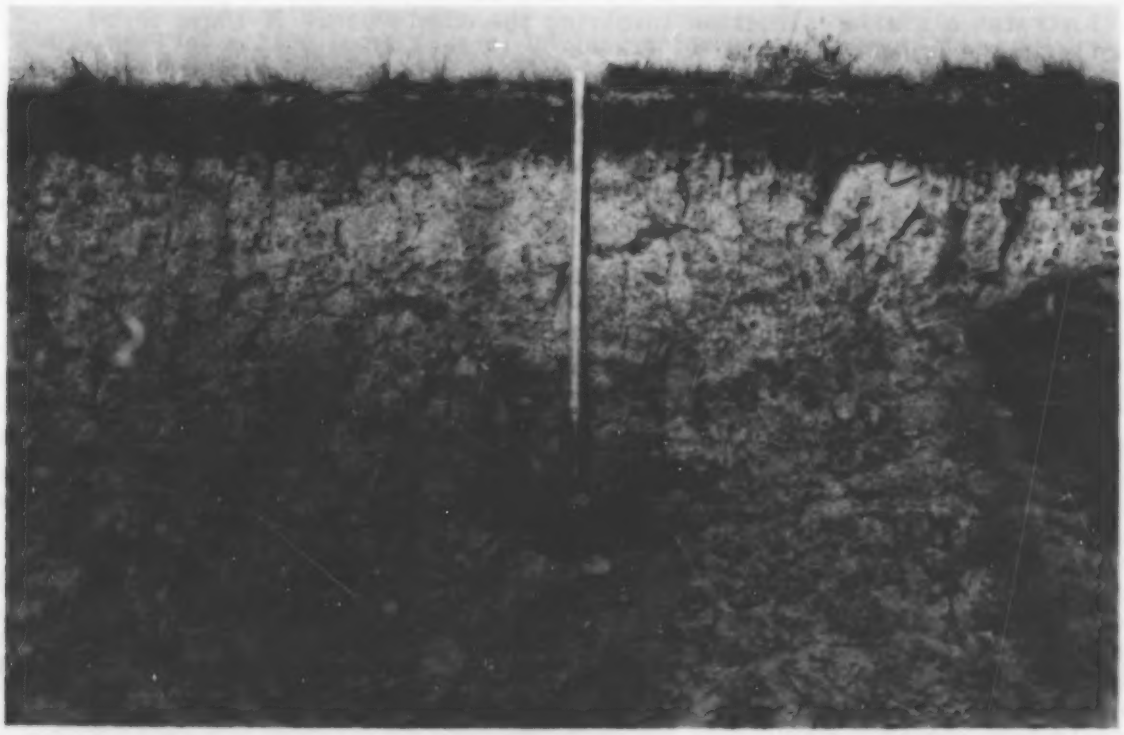


Figure 25. A road cut through a Maleb soil area.

Maleb compares favorably with any of the better soils in the county with regard to its potential for agriculture, whether for irrigation (where slopes are suitable), dryland farming, or grazing.

Millicent series (map symbol Mt)

Extent - 6560 ha (1.07% of total area)
Classification - Solonetzic Brown Chernozemic (formerly Eluviated Brown)
Usual surface texture - silty clay loam
Major associated series - Rosemary, Seven Persons
Parent material - fine clayey lacustrine
Associated landform - level and undulating
Slope range - 0.5-5%
Drainage - moderately well drained
Agricultural capability - 3 c
Irrigation rating - good
Grazing carrying capacity - 14-19 ha/AUY

Millicent soil, developed on lacustrine materials, has an eluviated A horizon from which clays have been leached into the underlying B horizon. Fine loamy to clayey textures and a friable structure further characterize this soil. The brown surface fades to grayish brown above the B horizon, which is generally dark brown; the C horizon is lighter brown. A $CaCO_3$ horizon is usually encountered at 25-30 cm below the surface.

Millicent soils are all found within Matzhiwin Plain in areas where lacustrine deposits are concentrated. Thus, the main area of Millicent is in the Rosemary-Gem locality, where associated soils are mainly Rosemary and Seven Persons and less frequently Patricia and Karlsbad. In this area, a few Millicent soils have been salinized after years of irrigation. Some Millicent soils also occur between Brooks and Millicent hamlet, where associated soils are mostly Rosemary and Seven Persons, and occasionally Chin. Generally, Millicent is the dominant member of the map unit, particularly in the areas south of Gem and around Rosemary.

For both irrigated and dryland agriculture, as well as grazing, Millicent soils are given a high rating. The fine texture is significant to dryland farming because of its greater moisture-holding capacity.

Purple Springs series (map symbol Pl)

Extent - 3765 ha (0.61% of total area)
Classification - Orthic Brown Chernozemic
Usual surface texture - loamy sand
Major associated series - Cavendish, Bingville
Parent material - sandy fluvial or eolian veneer over till
Associated landform - undulating and hummocky
Slope range - 2-15%
Drainage - rapidly to well drained
Agricultural capability - 5 m
Irrigation rating - poor
Grazing carrying capacity - 19-26 ha/AUY

The upper part of the Purple Springs profile resembles the Cavendish profile described in the Appendix. The one important difference is that Purple Springs has a IIC horizon of till at less than the 1-m depth. A brown Ah horizon about 20 cm thick gradually merges into the darker brown Bm horizon. Below this, at about 40-50 cm, the C horizon is pale brown. Loamy sand to sand textures are common in these three horizons, as is the loose single-grain structure. Slightly acid to neutral pH values in the upper profile gradually increase with depth. There is an abrupt change to the underlying clay loam till, which occurs at an average depth of 60-70 cm.

Purple Springs soils occur exclusively in Matzhiwin and Chin plains in locations with a sandy fluvial or eolian veneer over till. In the southern part of Matzhiwin Plain, north of Rolling Hills, fairly extensive areas of Purple Springs occur primarily in association with the Cavendish series. The series occurs elsewhere in Matzhiwin Plain, not in major concentrations but as the minor map unit component with a variety of other soils. Another fairly extensive area can be found in the portion of Chin Plain lying south of Lake Newell. There it forms either the major or minor map unit component with the Cavendish and Bingville series.

Because of their coarse texture, Purple Springs soils have a low rating for both irrigated and dryland agriculture. The wide texture differential between the upper sandy material and the underlying till creates a potential for lateral seepage, further limiting the irrigation potential. Although it has a relatively low carrying capacity, grazing is probably its best use as this diminishes the wind erosion hazard that exists under continued cultivation.

Patricia series (map symbol Pt)

Detailed description in Appendix
Extent - 8540 ha (1.39% of total area)
Classification - Brown Solodized Solonetz
Usual surface texture - silty clay loam
Major associated series - Rosemary, Millicent
Parent material - fine clayey lacustrine
Associated landform - level and undulating
Slope range - 0.5-5%
Drainage - moderately well drained
Agricultural capability - 4 d
Irrigation rating - poor
Grazing carrying capacity - 16-24 ha/AUY

The most obvious feature of the Patricia soil is its well developed solonetzic B horizon, developed in a fine clayey material. Above the Bnt horizon, both the Ah and Ae horizons are grayish brown friable silt loam. The fine columnar structure of the Bnt is very resistant to further breakdown. The lime horizon usually occurs at 30-40 cm, with salts below. Lower horizons are generally more alkaline than those closer to the surface.

Patricia soils are concentrated mainly in three areas, all within

Matzhiwin Plain. The largest is about 10 km northwest of Rosemary, within the lacustrine area stretching from Rosemary to Gem. Another considerable area is located southeast of Tilley and the third is south of Millicent. In these areas Patricia is mainly associated with the Rosemary series. However, in some areas where solonetzic features are less pronounced, Millicent is the major associated soil.

Because of the relatively flat topography associated with these lacustrine areas, it is not unusual to find poorly drained and saline soils associated with the better drained Patricia soil. Where this occurs, Gleddies is the main associated soil. Another important feature in some Patricia soil areas is the thinner-than-normal Ah horizon. These thin-phase Patricia soils, occurring south of Millicent as well as northwest of Rosemary, have an Ah less than 5 cm thick.

Another area of Patricia soils is located at the eastern edge of the county, about 12 km south of Dinosaur Provincial Park. This lacustrine area is part of the basin of Tide Lake, which is located just outside the county. The soils are badly eroded, to the point where they lack an Ah horizon. They have therefore been mapped as the eroded phase of Patricia in association with the eroded phase of the Rosemary series.

Because of their solonetzic features the Patricia soils have a relatively low agricultural rating, particularly for irrigation. For dryland crops and grazing, these characteristics are less limiting. Patricia soil areas that have a thin or absent Ah horizon are rated even lower than the normal Patricia soil.

Pemukan series (map symbol Pu)

Extent - 6800 ha (1.11% of total area)
Classification - Orthic Brown Chernozemic
Usual surface texture - sandy loam
Major associated series - Ramillies, Bingville, Foremost
Parent material - coarse loamy fluvial outwash
Associated landform - undulating and ridged, terraced
Slope range - 2-15%
Drainage - rapidly drained
Agricultural capability - 5 m
Irrigation rating - poor
Grazing carrying capacity - 24-32 ha/AUY

Pemukan soils can be recognized by the coarse textured material on which they have developed. The brown Ah horizon, about 10-12 cm thick, has a coarse sandy loam texture and a weak blocky structure. Colors change to dark brown in the Bm horizon, which is weak prismatic loam. Usually, the lime horizon occurs at 35-40 cm in pale brown coarse sandy loam. Coarse fragments (or gravel) are present in all horizons: about 5% by volume in the A horizon and 5-10% in the B horizon, gradually increasing with depth to a preponderance of gravel below 50 cm. Generally pH values are neutral in the A and B horizons and alkaline below.

Several areas of Pemukan soil occur in the County of Newell, many of which are good sources of gravel. Perhaps the largest single area is on the fluvial terrace in the Bow River valley west of Bow City, where Ramillies and Bingville are the associated soils. Similar terraced landforms in Crawling Valley also have developed Pemukan soils associated with the Bingville or Chin and Ramillies series (Fig. 26). Several upper-level terraces can be found along the banks of the Bow and Red Deer rivers, where Foremost and Bingville are the associated soils.

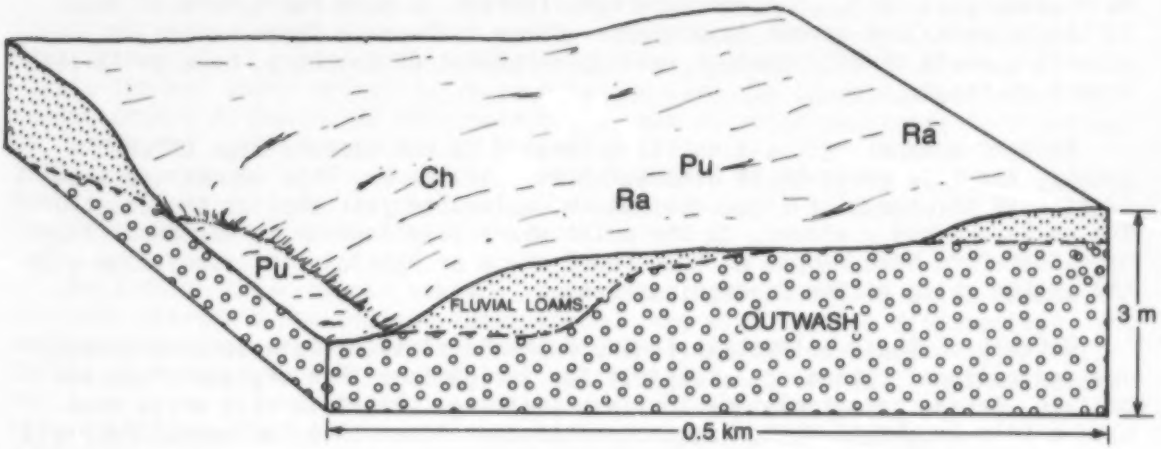



Figure 26. Cross-sectional diagram showing the relationship between the Pemukan series and some associated soils.

Fairly extensive Pemukan soil areas occur northeast of Bassano where the Crawling Valley spillway empties into Matzhiwin Plain. In these areas Pemukan is associated with a variety of soils, including Foremost, Ramillies, and Bingville. Elsewhere in Matzhiwin Plain, smaller spillways have deposited similar materials on which the Pemukan profile later developed. Some Pemukan soil has been mapped on coarse fluvial deposits on the rough area near Rolling Hills south of Lake Newell. There, associated soils are mainly Bingville, along with Cavendish and Purple Springs.

Generally, Pemukan soils are undesirable for cultivated agriculture because of their coarse texture and low water-holding capacity. Fig. 27 shows a Pemukan soil that should not have been cultivated because of the numerous areas where gravel close to the surface can be brought up by farm implements. Therefore, Pemukan areas are better left as native pasture even though their carrying capacity is relatively low. Probably their greatest value is as a source of gravel, particularly where they occur in association with the Ramillies series.

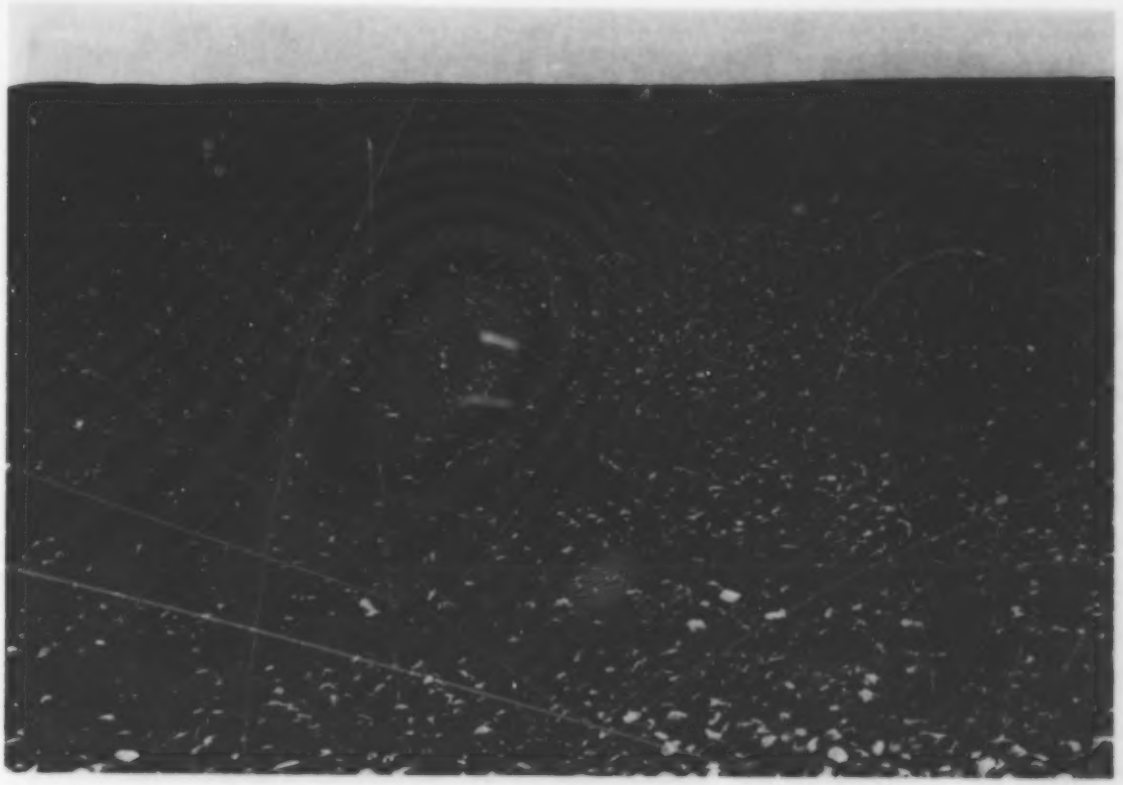


Figure 27. A Pemukan soil area. It should not have been cultivated.

Ramillies series (map symbol Ra)

Extent - 4985 ha (0.81% of total area)
Classification - Orthic Brown Chernozemic
Usual surface texture - loam to sandy loam
Major associated series - Pemukan, Bingville, Chin
Parent material - fine to coarse loamy fluvial veneer over outwash
Associated landform - undulating, terraced
Slope range - 2-9%
Drainage - rapidly drained
Agricultural capability - 4 m
Irrigation rating - fair
Grazing carrying capacity - 16-24 ha/AUY

Ramillies soils can be recognized by their two-tiered profile in which a veneer of loamy fluvial material overlies fluvial sands and gravels. The upper part of the profile resembles Chin, except for slightly coarser textures. An Ah horizon about 10-12 cm thick is brown and weakly granular. There is a gradual change to the yellowish brown Bm horizon of weak prismatic loam to heavy loam. A lime horizon is usually encountered around the 35-cm depth. Most Ramillies profiles change abruptly to the underlying coarse material, which usually has a high content of coarse fragments (Fig. 28). A

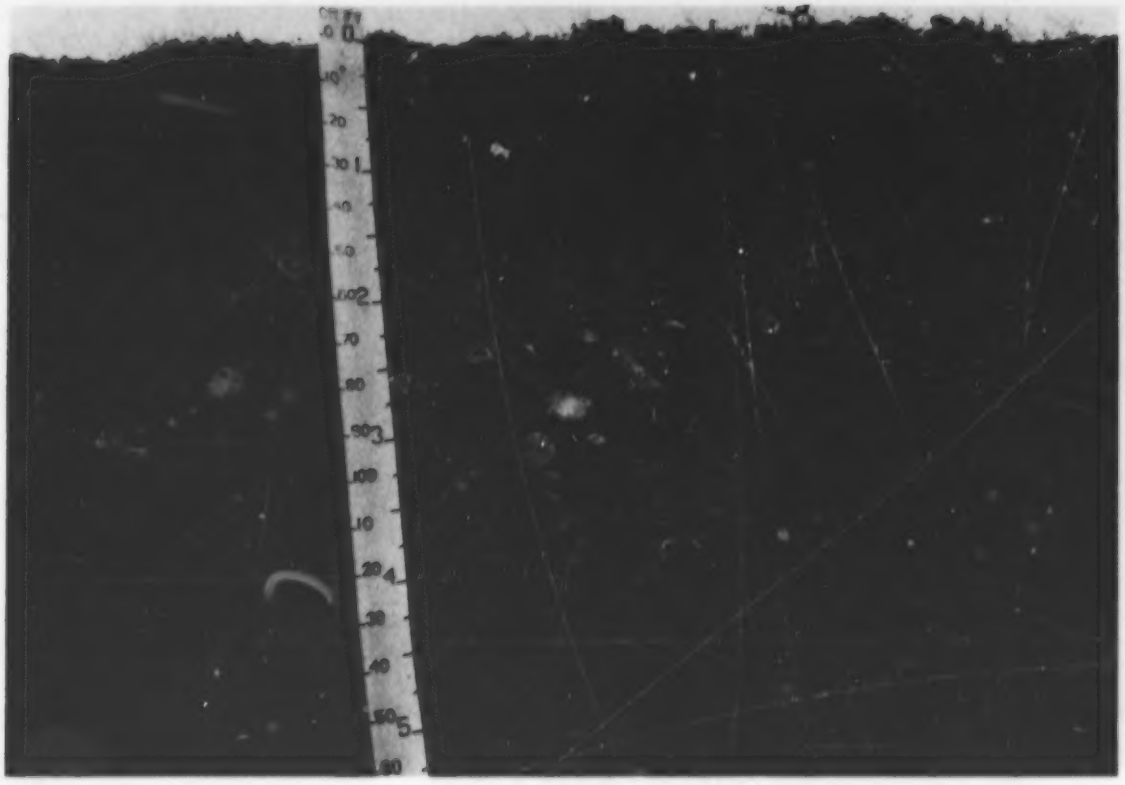


Figure 28. Cut through a Ramillies soil area.

neutral reaction is common in the A and B horizons whereas horizons below are alkaline. Coarse subsoils may occur at depths varying from 30 cm to almost 1 m.

Most of the Ramillies series mapped in the county is associated with terraced landforms, located either in modern river valleys or in post-glacial spillways. Thus, a considerable area is found in the valley of Bow River where associated soils are mainly Pemukan, Bingville, and Chin (Figure 26). Several terraces occur in Crawling Valley where Ramillies is associated with Bingville and Pemukan. Along with the Pemukan series, Ramillies is found on many of the upper-level terraces along the banks of Bow River and, in particular, along the banks of Red Deer River in the northern part of the county. Ramillies is also part of the complex of soils formed on the fluvial deposits from the spillways emptying into Matzhiwin Plain, the most noticeable being the area northeast of Bassano. About 12 km southwest of Tilley, Ramillies has been mapped on a barely discernible low ridge about 8-9 km long. The Ramillies soil in this narrow area differs from normal in that its subsoil is composed entirely of sands and contains no coarse fragments. A similar type of Ramillies occurs in the area immediately north of Brooks, in association with Bingville and Chin soils.

Ramillies soils do not have a high rating for either irrigated or dryland farming, primarily because of the coarse subsoil. For the same reason their carrying capacity for grazing is relatively low. Generally, Ramillies soil areas are a good source of gravel, particularly when they occur in association with Pemukan soil.

Rolling Hills series (map symbol Rh)

Detailed information in Appendix
Extent - 6390 ha (1.04% of total area)
Classification - Brown Solodized Solonetz
Usual surface texture - loamy sand
Major associated series - Cavendish, Rolward, Bingville
Parent material - sandy fluvial or eolian veneer over fluvial or lacustrine
Associated landform - undulating and low-relief hummocky
Slope range - 2-9%
Drainage - rapidly to well drained
Agricultural capability - 4 m
Irrigation rating - non-irrigable
Grazing carrying capacity - 19-24 ha/AUY

The most distinctive feature of the Rolling Hills soil is the sandy veneer overlying the fine textured material in which solonetzic development has taken place. A weak granular structure in the overlay becomes less apparent with depth, with a corresponding graying of the brown colors. There is an abrupt change to the strongly structured solonetzic horizon below, which has a fine clayey texture. Acidic conditions prevail in the sandy overlay whereas alkaline conditions are present in the lower profile. Textures in the upper part of the soil described in the Appendix are finer than normal for the Rolling Hills series. The texture in the lime horizon is also finer than normal. Although there were no salts present in the lower horizons of the sampled soil, they are often present in other Rolling Hills soils.

All Rolling Hills soil areas mapped in the county are within Matzhiwin Plain. The largest concentration is in the sandy area north of Rolling Hills hamlet, most of which is underlain by fluvial or lacustrine material at depths varying from a few centimetres to more than 1 m. In areas where the overlay becomes deeper, the Rolling Hills series is found associated mainly with the Cavendish or Bingville series. Where thinner overlays occur, the associated soils are mainly the Rolward and Rainier series, and the Wardlow series where little or no sandy overlay is present (Fig. 29). Some Rolling Hills soils have been mapped in the sandy area between Bassano and Rosemary, mainly as the minor map unit component with Cavendish and to a lesser extent Youngstown. In the sandy area around Patricia, some of the Cavendish soils mapped have Rolling Hills as the minor map unit component. Many of these Rolling Hills soils have become salinized, presumably from the cumulative effect of years of laterally moving irrigation waters.

The widely contrasting textures that characterize the Rolling Hills series are mainly responsible for its non-irrigable rating. Under dryland agriculture, this textural difference diminishes moisture loss through downward percolation, so in that sense it is beneficial. Wind erosion could occur under a system of continuous cultivation, a hazard that can be diminished by permanent pasture or hay crop production.

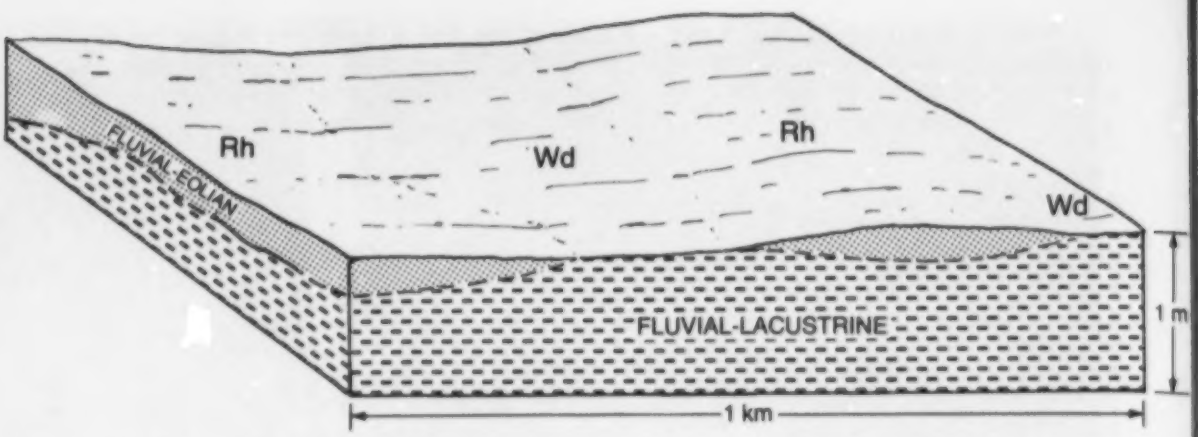



Figure 29. Cross-sectional diagram showing a Rolling Hills-Wardlow soil complex.

Rainier series (map symbol Ri)

Detailed information in Appendix
Extent - 7285 ha (1.19% of total area)
Classification - Orthic Brown Chernozemic
Usual surface texture - sandy loam
Major associated series - Bingville, Chin, Antonio, Rolling Hills
Parent material - coarse loamy fluvial veneer over fluvial or lacustrine
Associated landform - level and undulating
Slope range - 0.5-5%
Drainage - well drained
Agricultural capability - 4 m
Irrigation rating - fair
Grazing carrying capacity - 16-19 ha/AUY

Rainier is another of several soils in the county that are characterized by a sandy veneer overlying a finer textured material of a different depositional origin. This soil has a granular sandy loam A horizon and usually has a similar or finer texture in the B horizon. However, the Rainier soil sampled and described in the Appendix has a loamy sand texture in the B horizon. The underlying material usually is a silt loam or finer and is quite mellow. Considerable variation can occur in the thickness of overlay, from 25 cm to nearly 1 m. Profile colors, grayish brown at the surface, change to yellowish brown in the subsoil. Near-neutral pH values prevail above the alkaline lime horizon. In the described profile, till was encountered at a depth of 78 cm, but usually it is much deeper.

Rainier occurs in two main areas in the county. One is in Chin Plain, mainly in the Scandia-Rainier area, where Bingville and Chin comprise the main associated soils. In portions of this area where underlying till is even closer than at the sample site, Antonio is the associated soil. These relationships are illustrated in Figure 13. The second major area of Rainier

soils is in the southern part of Matzhiwin Plain around Rolling Hills. South of the hamlet, where soils tend to be finer texture, Chin and Bingville are the dominant map unit component associated with Rainier. In the sandier area north of Rolling Hills where underlying materials tend to be more solonetzic, associated soils are Rolling Hills and Bingville. A few small isolated areas of Rainier occur elsewhere in Matzhiwin Plain, usually as a minor map unit component with a variety of other soils.

The two-tiered sequence of parent materials can pose a problem where Rainier soil is irrigated. However, the problem should not be too serious because textural difference between the two materials is relatively narrow. For dryland and grazing purposes the soil is comparable to other similar-textured soils.

Rosemary series (map symbol Rm)

Detailed information in Appendix
Extent - 9550 ha (1.56% of total area)
Classification - Brown Solod
Usual surface texture - silty clay loam
Major associated series - Patricia, Millicent
Parent material - fine clayey lacustrine
Associated landform - level and undulating
Slope range - 0.5-5%
Drainage - moderately well drained
Agricultural capability - 4 d
Irrigation rating - poor
Grazing carrying capacity - 14-19 ha/AUY

Rosemary soils have grayish brown surface horizons which become grayer just above the B horizon. There is a noticeable structural breakdown at the top of the B horizon, a characteristic common to Solods. As noted, subsoil materials have a high content of clay as well as some salts. The alkaline reaction of the upper horizons of the soil described is unusual; it has probably been brought about by land-leveling operations in the area from which the sample was collected.

Rosemary soils occur in two main areas within Matzhiwin Plain. One is the area of lacustrine soil between the hamlet of Gem and the village of Rosemary from which the soil derives its name. In this area, Rosemary has been mapped as either the major or minor map unit component, primarily with Patricia and Millicent soils. Salinization of the Rosemary profile is evident at several locations in this lacustrine area. In areas where salinity is more severe and drainage is poor, the Gleddies series is included in the map unit. The second major area of Rosemary lies south of the hamlet of Millicent. There, in addition to Patricia and Millicent soils, Rosemary is also found in association with the thin phase of Patricia.

Another significant area of occurrence is at the eastern side of the county in the Tide Lake area. As was mentioned earlier when discussing the Patricia series, the soils in this area lack any appreciable Ah horizon,

possibly due to wind erosion. These Rosemary soils have therefore been mapped in association with the Patricia soils that have been similarly altered.

The solonetzic characteristics of the Rosemary soil are the main factors that limit its agricultural use. These characteristics are even more limiting when the soil is irrigated. Rosemary soils with the abnormal characteristics of salinity and lack of topsoil have an even lower rating for all agricultural uses.

Ronalaine series (map symbol Ro)

Detailed information in Appendix
Extent - 14 655 ha (2.4% of total area)
Classification - Solonetzic Brown Chernozemic
Usual surface texture - loam
Major associated series - Cecil, Maleb, Halliday, Hemaruka
Parent material - fine loamy till
Associated landform - undulating and hummocky
Slope range - 2-30%
Drainage - well drained
Agricultural capability - 4 m
Irrigation rating - good
Grazing carrying capacity - 14-19 ha/AUY

Ronalaine soils can be recognized by the blocky structure of the B horizon, which at first glance appears similar to the B horizon of soils belonging to the Solonetzic order. However, the structure is not as hard, nor are the ped surfaces darkly stained as they are in Solonetzic soils. The Ronalaine soil has no Ae horizon and its Ah horizon is relatively thin. Brown colors in the upper part of the profile become lighter with depth. Except for a neutral reaction in the topsoil, alkaline pH values are prevalent throughout the profile. As indicated in the Ronalaine profile described in the Appendix, all horizons generally have a loam to clay loam texture.

This soil is fairly extensive in both parts of Kininvie Plain. In the portion east of Matzhiwin Plain it is most prevalent in the south where it occurs most frequently with the Halliday and Hemaruka series. To the west of Matzhiwin Plain, Ronalaine has been mapped almost as often with the Cecil and Maleb series as with Halliday and Hemaruka. Ronalaine soils in western Kininvie Plain are concentrated along the southern and western parts. Some Ronalaine soils were also mapped between Brooks and Lake Newell in association with the Steveville and Hemaruka soils. Although Ronalaine is the major soil in some map units, in most it is the minor soil.

Ronalaine soils have no major limitation to use for agriculture. Few areas are being cultivated, however, probably because Ronalaine generally occurs with soils that are inferior, particularly for irrigation purposes.

Rolward series (map symbol Rr)

Extent - 3965 ha (0.65% of total area)
Classification - Brown Solodized Solonetz
Usual surface texture - sandy loam
Major associated series - Rolling Hills, Bingville, Wardlow
Parent material - coarse loamy fluvial veneer over fluvial or lacustrine
Associated landform - undulating and low hummocky
Slope range - 2-9%
Drainage - well drained
Agricultural capability - 4 m
Irrigation rating - non-irrigable
Grazing carrying capacity - 16-19 ha/AUY

The most distinctive feature of Rolward soil is the coarse loamy veneer overlying fine loamy material in which a solonetzic B has developed. The Rolward profile consists of a brown to dark grayish brown Ah horizon up to 15 cm thick. Toward its lower boundary, colors grade to grayish brown and continue becoming grayer as far as the pale brown Ae horizon at 25-30 cm. Textures in these upper horizons are sandy loam tending toward loamy sand in the Ae horizon. There is an abrupt change into the Bnt horizon at 35-40 cm below the surface. The Bnt and lower horizons are similar to the equivalent horizons in the Wardlow profile. The Bnt horizon is dark brown and strongly columnar, with dark staining on the ped surfaces. Structural characteristics gradually weaken with depth, until no structure is evident in the yellowish brown C horizon. Lime is generally encountered at or near the 60-cm depth. Silty clay loam textures are consistent at these lower depths where salts usually occur. pH values are weakly acid to neutral in the A horizon, increasing to alkaline in the underlying material.

Rolward soils are concentrated in the sandy area around and north of Rolling Hills hamlet. The series is most often found in association with the Rolling Hills and Bingville series where the sandy overlay is continuous. In locations where the overlay is discontinuous and fine loamy material appears at the surface, Wardlow is the associated soil. In the Rolling Hills area, Rolward soils have been mapped as both the minor and major map unit component. This soil occurs in a few small areas elsewhere in Matzhiwin Plain. One is in the Patricia area, where it has been mapped in association with the Bingville and Youngstown soils. Between the villages of Rosemary and Duchess, Rolward also occurs in association with Bingville and Youngstown, mainly as the minor map unit component.

Rolward soils are considered to be non-irrigable because of the solonetzic horizon below the sandy veneer, a situation conducive to seepage and salinization. Because of the coarse texture, this soil also has a relatively low rating for both grazing and arable agriculture.

Scollard series (map symbol Sc)

Extent - 1050 ha (0.17% of total area)
Classification - Orthic Dark Brown Chernozemic
Usual surface texture - sandy loam
Major associated series - Crowfoot, Lethbridge, Wainwright
Parent material - coarse loamy fluvial outwash
Associated landform - undulating and ridged, terraced
Slope range - 2-15%
Drainage - rapidly drained
Agricultural capability - 4 m
Irrigation rating - poor
Grazing carrying capacity - 19-24 ha/AUY

The coarse texture and gravel content are the most significant features of the Scollard soil. Dark grayish brown surface colors change gradually to dark brown in the Bm horizon, 12-14 cm deep. Yellowish brown colors are usual in the lime horizon which occurs at depths varying from 35 to 45 cm. A weak blocky structure in the A horizon changes to weak prismatic in the B horizon, a change that corresponds to the sandy loam texture in the A horizon and the loam in the B horizon. Gravel and stones are present in all horizons, the amount increasing with depth from about 5% in the A horizon to over 50% in the subsoils. Near-neutral pH values prevail in the A and B horizons increasing to alkaline in the lime horizon and lower. This soil is similar to Pemukan, the main difference being in the topsoil colors.

Apart from a few small areas in Bow River valley at the western edge of the map area, Scollard soils occur almost exclusively in the northern end of Crawling Valley. There, they occur mainly on terraced landforms as the major map unit component with Lethbridge and Wainwright soils. In the valley of Bow River, Scollard occurs as the minor map unit component with the Lethbridge and Crowfoot series, also on terraced landforms.

Scollard series have a low rating for all agricultural uses, because of the low water-holding capacity of the coarse and gravelly material on which they have developed. Probably the greatest value of Scollard soil areas is as a possible source of gravel.

Scotfield series (map symbol Sf)

Extent - 1010 ha (0.16% of total area)
Classification - Orthic Regosol, saline phase
Usual surface texture - loam
Major associated series - Stirling, Gleddies, Patricia
Parent material - fine loamy fluvial or lacustrine
Associated landform - level and undulating
Slope range - 0.5-5%
Drainage - moderately well drained
Agricultural capability - 6 n
Irrigation rating - non-irrigable
Grazing carrying capacity - greater than 49 ha/AUY

Scotfield soils can be recognized by their lack of profile development and by the salts visible on the surface and in the upper profile. In some locations there may be a weakly developed loam to silt loam A horizon a few centimetres thick. It is dark grayish brown with a weak fine granular structure. Below this, uniform dark grayish brown colors continue in silt loam to silty clay loam. Usually this deeper material has a low lime content. There is no discernable structure in the subsoil, which is usually wet and sticky.

This soil is concentrated in some of the groundwater discharge areas about 12 km northwest of Rosemary. These are flat areas dominated by Solonetzic soils and fine textured materials. Evidence of groundwater discharge activity is indicated by numerous small "puffy" and slightly elevated surfaces. They are a few metres in size and are usually too saline to support even the most salt-tolerant vegetation. These bare areas have been mapped as Scotfield mainly because they lack any profile development. In some areas, Scotfield has been mapped as the minor map unit component with Sterling and the thin phase of Patricia, as well as Gleddies where poorly drained conditions are obvious.

Because of their salinity, Scotfield soil areas are unsuitable for both irrigated and dryland crop production. Despite the extremely low carrying capacity, grazing is still their main agricultural use.

Sterling series (map symbol Sg)

Extent - 3320 ha (0.54% of total area)
Classification - Brown Solonetz
Usual surface texture - silty clay loam
Major associated series - Patricia, Rosemary, Scotfield
Parent material - fine clayey lacustrine
Associated landform - level and undulating
Slope range - 0.5-5%
Drainage - moderately well drained
Agricultural capability - 5 d
Irrigation rating - non-irrigable
Grazing carrying capacity - 24-32 ha/AUY

Sterling soils can be recognized by their thin Ah and abrupt boundary to the solonetzic B horizon. The A horizon, about 5 cm thick, has a granular structure and a silty clay loam texture, and is dark grayish brown. The coarse blocky Bnt horizon is very hard, very dark gray silty clay. Lime and salts usually occur at or just below the 30-cm depth in dark gray silty clay loam. pH values are neutral to slightly acid in the A horizon, neutral to mildy alkaline in the B horizon, and moderately to strongly alkaline in the subsoil.

Major concentrations of Sterling soil are located in the Rosemary-Gem area. There it forms both major and minor map unit components with Patricia and Rosemary soils. Most of the associated Patricia soil is the thin phase, which has an Ae whereas Sterling does not. Some of the Sterling soil in this area has also been salinized. Similar areas occur east of Tilley, bordering

on Kininvie Plain. The northern part tends to be poorly drained, resulting in a map unit that includes the Walsh series. Several small isolated areas of Sterling soil occur elsewhere in Matzhiwin Plain.

The thin topsoil and solonetzic characteristics of the Sterling soil are responsible for its low rating for both dryland and irrigated agriculture. These characteristics also result in a relatively low grazing carrying capacity.

Steveville series (map symbol Si)

Detailed information in Appendix
Extent - 12 180 ha (1.99% of total area)
Classification - Brown Solodized Solonetz
Usual surface texture - loam
Major associated series - Hemaruka, Halliday, Ronalaine
Parent material - fine loamy soft rock
Associated landform - undulating and rolling
Slope range - 2-15%
Drainage - moderately well drained
Agricultural capability - 5 d
Irrigation rating - non-irrigable
Grazing carrying capacity - 19-24 ha/AUY

The most obvious features of the Steveville profile are the solonetzic B horizon and the soft rock parent material. One distinct characteristic of this soft rock is the extremely hard "baking" that occurs when it is exposed. This baking is noticeable in any roadcut through a Steveville area. Surface horizons usually are brown and weakly structured, particularly in the Ae horizon. The Bnt horizon has the hard columnar structure characteristic of Solodized Solonetz profiles. Loam to clay loam textures prevail in the subsoil which generally has alkaline pH values. Lime occurs at or near the 40-cm depth, and salts usually occur at lower depths.

Although the parent material is soft rock it is usually modified, particularly near the surface, where it is hard to distinguish from any overlying till. Most Steveville areas are overlain by till of varying thickness, ranging from a few centimetres to nearly half a metre. However, areas with a deeper till overlay are not considered as a Steveville soil but are either Hemaruka or Halliday depending on profile development. These areas are difficult to map, not only because of the variation in thickness of till overlay but because the two materials merge into one another. Thus, these areas usually are a complex association of Steveville in various combinations with the Hemaruka and Halliday soils (Fig. 30).

Steveville soils are concentrated in the eastern portion of Kininvie Plain, mainly in the area between Cowoki Lake and Dinosaur Provincial Park. In this undulating to rolling soft rock plain, eroded pits are a common landscape feature, even more prominent than in other solonetzic areas in the county. This soil was also mapped at the north end of Lake Newell where Ronalaine and Hemaruka are the associated soils. Another small area of Steveville was mapped about 10 km southeast of Bassano, where Hemaruka and

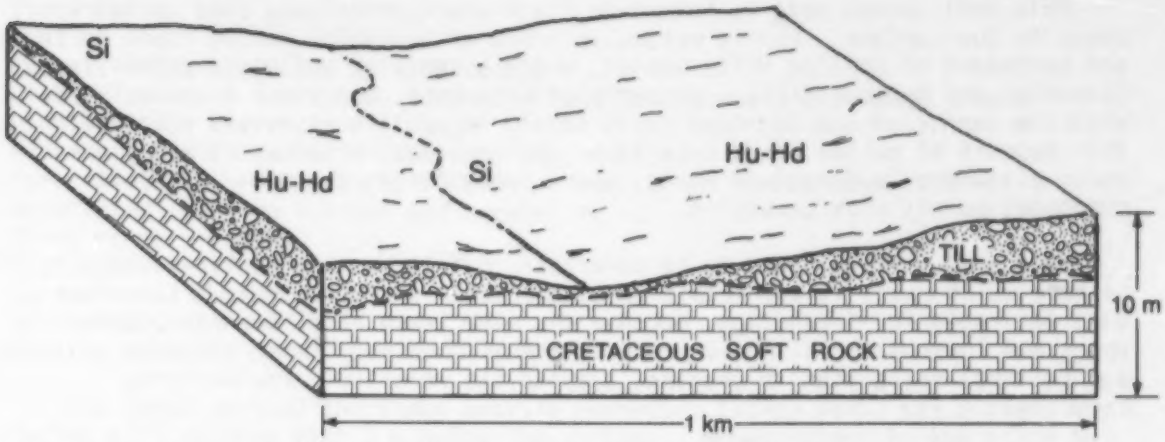



Figure 30. Cross-sectional diagram showing the relationship between Solonetzic soils on till and soft rock materials.

Halliday form the associated soils. This area, in addition to having numerous eroded pits, is also very stony.

This soil, because of its solonetzic characteristics and the undesirable features of the soft rock material, has little or no potential for cultivated agriculture, either dryland or irrigated. Even though it has a relatively low carrying capacity, grazing is still its best agricultural use.

Sunnynook series (map symbol Sk)

Extent - 3200 ha (0.5% of total area)
Classification - Brown Solodized Solonetz
Usual surface textures - loamy sand
Major associated series - Cavendish, Rolling Hills
Parent material - sandy fluvial or eolian veneer over till
Associated landform - undulating and hummocky
Slope range - 2-15%
Drainage - rapidly to well drained
Agricultural capability - 5 md
Irrigation rating - non-irrigable
Grazing carrying capacity - 19-24 ha/AUY

Sunnynook soils can be recognized by the sandy veneer overlying till in which a Solodized Solonetz profile has developed. Depth of sandy overlay can be quite variable but usually averages 40-50 cm. Brown colors at the surface grade to yellowish brown, and then to pale brown in the Ae horizon at 8-10 cm above the solonetzic B horizon. This upper material has a loamy sand to sand texture and a very weak granular to single grain structure. Slightly acid to neutral pH values are common in this sandy material. The IIBnt horizon developed in the underlying till is dark brown with a very hard columnar round-topped structure. Below this, a lime horizon occurring at about 60 cm is pale brown alkaline clay loam.

This soil occurs only in Matzhiwin Plain where underlying till is fairly close to the surface. Fairly extensive areas of Sunnynook can be found north and northeast of Rolling Hills hamlet, where associated soils are primarily Cavendish and Rolling Hills. In parts of this area, Sunnynook is associated with the Vendisant and Antelope soils mainly in areas that have a relatively thin deposit of eolian sands over till. Several smaller areas of Sunnynook occur elsewhere in Matzhiwin Plain, where Sunnynook is the minor map unit component mainly with Cavendish.

This soil is considered to be nonarable, mainly because of its sandy texture which makes it vulnerable to wind erosion if cultivated. It is even less desirable for irrigation, because the wide textural difference between upper and lower material would promote lateral seepage. Thus, its main agricultural value lies in grazing, despite its relatively low carrying capacity.

Seven Persons series (map symbol Sp)

Extent - 3765 ha (0.61% of total area)
Classification - Orthic Brown Chernozemic
Usual surface texture - silty clay loam
Major associated series - Millicent, Rosemary, Tilley, Chin
Parent material - fine clayey lacustrine
Associated landform - level and undulating
Slope range - 0.5-5%
Drainage - moderately well drained
Agricultural capability - 3 c
Irrigation rating - good
Grazing carrying capacity - 14-19 ha/AUY

The most significant feature of the Seven Persons soil is its fine texture. It has a grayish brown Ah horizon about 10 cm thick with a granular structure and a silty clay loam texture. The B horizon is dark grayish brown silty clay loam to silty clay. This horizon, about 25 cm thick, is further characterized by a blocky to irregular prismatic structure. A lime horizon usually occurs at the 35-40 cm depth, in olive brown silty clay loam. Similar-textured materials continue to 1 m and below. Salts sometimes occur at these lower depths.

Seven Persons soils occur in two main areas, both within Matzhiwin Plain. One is around and between Rosemary and Gem, where this soil is primarily associated with Millicent and Rosemary soils. The second area lies southeast of Duchess where, in addition to Millicent, the associated soils are Tilley and Chin. The Seven Persons soils in this area are not as fine textured as those in the Rosemary-Gem area. There is evidence that some Seven Persons soils are becoming salinized through continued irrigation. Seven Persons has been mapped as both the major and minor map unit components.

Seven Persons soils are among the best agricultural soils in the county. The fine texture and associated high water-holding capacity make them more desirable for dryland farming than most other soils.

Timko series (map symbol Ti)

Extent - 4900 ha (0.80% of total area)
Classification - Solonetzic Brown Chernozemic (formerly Eluviated Brown)
Usual surface texture - silt loam
Major associated series - Cranford, Gem, Duchess
Parent material - fine loamy fluvial or lacustrine veneer over till
Associated landform - level and undulating
Slope range - 0.5-9%
Drainage - well drained
Agricultural capability - 4 m
Irrigation rating - good
Grazing carrying capacity - 14-19 ha/AUY

The upper part of the Timko profile resembles Tilley soil, but differs in having till at less than 1 m below the surface. Brown colors in the silty Ah horizon change to grayish brown in the Ae horizon about 15 cm below the surface. The Ah horizon has a weak subangular blocky to granular structure which is very friable. Usually the Ae horizon is about 5 cm thick and has a very weak platy structure. Textures in the B horizon are silt loam to silty clay loam. This horizon, about 20 cm thick, is dark brown and friable prismatic. Underlying clay loam till occurs anywhere from 25 cm to nearly 1 m below the surface. With this variation in depth to till, the lime horizon may occur in the overlay or in the till. pH values range from neutral to slightly acid in the A horizon to mildly alkaline in the B horizon and moderately alkaline in lower horizons.

Timko soils occur primarily near the edges of Matzhiwin and Chin plains, where depth to till is less than in the more central portions of these two plains. In Matzhiwin Plain this soil is found in several locations, but mainly in the southern half. Major concentrations occur between Brooks and Duchess, as well as in an area south and east of Rolling Hills. In Chin Plain, Timko soils occur most frequently in the northern part both as minor and major components of the map unit. This is also true of the Timko soils in Matzhiwin Plain.

Although Timko soils have a relatively high irrigation rating, lateral movement of irrigation water may occur along the interface between the two materials. This problem is more acute in Timko soils that have coarser than normal material just above the till, which is more conducive to seepage. For dryland agriculture and grazing, Timko soils compare favorably with other soils in the county.

Tilley series (map symbol Ty)

Detailed information in Appendix
Extent - 22 540 ha (3.68% of total area)
Classification - Solonetzic Brown Chernozemic (formerly Eluviated Brown)
Usual surface texture - silt loam
Major associated series - Chin, Karlsbad, Wardlow, Bingville
Parent material - fine loamy fluvial or lacustrine
Associated landform - level, undulating, and low hummocky
Slope range - 0.5-9%
Drainage - well drained
Agricultural capability - 4 m
Irrigation rating - good
Grazing carrying capacity - 14-19 ha/AUY

Tilley soils have developed a brownish profile in a uniform material of silt loam to silty clay loam. The A horizons may be up to 25 cm thick above the prismatic B horizon. A lime horizon of moderate concentration usually occurs at or near the 40-50 cm depth. Neutral pH values in the A horizon increase to mildly alkaline in the B horizon and moderately alkaline in the lime horizon.

Almost all the Tilley soils mapped in the county were found within Matzhiwin Plain. Extensive areas occur from Brooks to Millicent to Duchess, where the main associated soil is Chin with lesser occurrences of Chinz and Timko. Closer to Brooks, where textures are somewhat coarser, Bingville is the main associated soil. Tilley soils are also widespread around and west of the village of Tilley, from which this soil derives its name. There Chin is again the dominant associated soil. However, in a significant number of map units where soils tend to be more solonetzic, Karlsbad and Wardlow are the associated soils. In the Rosemary-Gem area also, these two Solonetzic soils are often associated with Tilley. There are other smaller areas in Matzhiwin Plain where Tilley has been mapped with a variety of other soils. It is interesting to note that very little Tilley soil occurs in Chin Plain.

This soil compares favorably with all the better irrigation soils in the county. However, because it is located in an area of relatively low rainfall, it has some limitations for dryland agriculture.

Ventre series (map symbol Ve)

Extent - 2750 ha (0.45% of total area)
Classification - Rego Gleysol
Usual surface texture - silt loam
Major associated series - several
Parent material - fine loamy fluvial or lacustrine
Associated landform - level and depressional
Slope range - 0-2%
Drainage - poorly drained
Agricultural capability - 5 w
Irrigation rating - non-irrigable
Grazing carrying capacity - 8-10 ha/AUY

Ventre soil can be recognized by its dull profile colors. It occurs in shallow depressions or level lowlands. Usually Ventre has a loose surface A horizon, about 2 cm thick, of dark grayish brown silt loam. Below this the C horizon generally is olive gray with brownish mottles, particularly in the lower C horizon. A silty clay loam texture prevails in this horizon which generally has a massive structure. However, a coarse irregular blocky structure may develop in the upper C in late summer when drier conditions occur. The A horizon is usually neutral to mildly alkaline and lower horizons are mildly to moderately alkaline. Low concentrations of lime are present in the C horizon.

Ventre soils occur in low, poorly drained locations, many of which are too small to map. This results in map units where Ventre is the minor map unit component. However, the soil has developed in several larger depressions, many of which occur in Matzhiwin Plain as well as in the southern part of Kininvie Plain. Those in Kininvie Plain are primarily the result of infilling of depressions with material from the immediate surrounding areas, whereas those in Matzhiwin Plain resulted from depressions in already existing fluvial or lacustrine material, with little or no infilling. Thus the main difference between Ventre soils in the two locations is in depth of material: a thicker deposit for those in Matzhiwin Plain, and a thinner deposit over till for those in Kininvie Plain.

Because of their location in the landscape, Ventre soils are non-irrigable. Unless some artificial drainage can be provided, they are also unsuitable for dryland cropping. However, the poorly drained conditions give this soil a relatively high carrying capacity for grazing.

Verdigris series (map symbol Vg)

Extent - 2845 ha (0.46% of total area)
Classification - Cumulic Regosol
Usual surface texture - loam
Major associated series - Expanse
Parent material - fine to coarse recent alluvium
Associated landform - level, terraced
Slope range - 0.5-2%
Drainage - well drained
Agricultural capability - 5 f
Irrigation rating - poor
Grazing carrying capacity - 19-32 ha/AUY

Verdigris soils can be recognized by the multilayered or cumulic appearance of the profile (Fig. 31). No discernible profile has developed in the recent fluvial deposit, which is weakly to moderately calcareous to the surface. Textures are generally very fine sandy loam to loam with little or no structural characteristics. At lower profile depths, layers of coarser material are common between layers of loamy material. Brown to grayish brown colors at the surface continue well into the profile, with only slight variations.

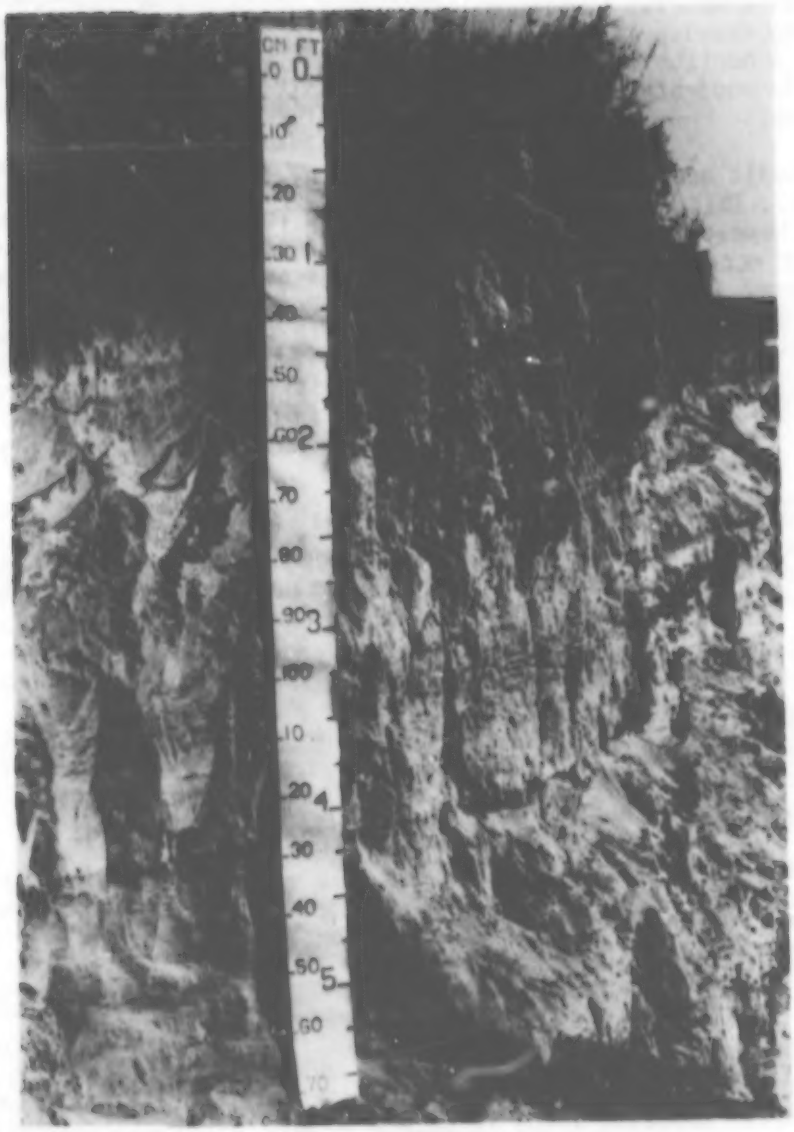



Figure 31. Soil profile of the Verdigris series.

This soil is found only in the valleys of Bow and Red Deer rivers on recently formed level terraces. As with most fluvial deposits there can be considerable textural variation, ranging from sandy to clayey, which is most obvious in the subsoils. Soils in the valley of Bow River generally appear to have a better profile development than those in the valley of Red Deer River. Thus, in the Bow River Valley, Verdigris was mapped in association with the Expanse series, while in the Red Deer valley no other soils were mapped with the Verdigris soil.

Because of its low fertility level, this soil has a relatively low rating for all agricultural uses.

Vendisant series (map symbol Vs)

Detailed information in Appendix
Extent - 7970 ha (1.30% of total area)
Classification - Rego Brown Chernozemic
Usual surface texture - loamy sand
Major associated series - Antelope, Cavendish, Yarnley
Parent material - sandy fluvial or eolian
Associated landform - undulating and ridged
Slope range - 2-15%
Drainage - rapidly drained
Agricultural capability - 6 m
Irrigation rating - non-irrigable
Grazing carrying capacity - 24-32 ha/AUY

The main features of the Vendisant soil are the sandy texture and the very weak profile development. This development is limited to a slight organic matter accumulation in the upper horizon as evidenced by the slightly darker colors compared with those below. A loose single grain structure is common to all horizons. Neutral pH values in the upper part of the profile gradually turn to alkaline in the lower part.

Two main areas of Vendisant soil occur in the county, both in Matzhiwin Plain and both associated with dune sands. One area lies north of Duchess more or less between Matzhiwin Creek and Red Deer River. The second lies north of Rolling Hills. In both areas Vendisant is associated with Antelope and Cavendish soils in an intermediate landscape position between them (Figure 14). With respect to profile development, Vendisant represents the intergrade or intermediate profile between Antelope (Orthic Regosol) and Cavendish (Orthic Brown Chernozemic). In a few sandy areas with solonetzic tendencies, Vendisant has been mapped in association with Yarnley soil.

Because of their sandy character and associated low water-holding capacity and susceptibility to wind erosion, Vendisant soils are nonarable. Despite the low carrying capacity, grazing is still the best agricultural use.

Wardlow series (map symbol Wd)

Detailed information in Appendix
Extent - 11 945 ha (1.95% of total area)
Classification - Brown Solodized Solonetz
Usual surface texture - silt loam
Major associated series - Karlsbad, Tilley, Duchess, Chin
Parent material - fine loamy fluvial or lacustrine
Associated landform - undulating and low-relief hummocky
Slope range - 2-9%
Drainage - moderately well drained
Agricultural capability - 4 d
Irrigation rating - poor
Grazing carrying capacity - 16-24 ha/AUY

Wardlow can be recognized by its hard columnar round-topped B horizon developed in a stone-free fluvial or lacustrine material. The brownish friable A horizon is up to 20 cm thick. The change to the B horizon is very abrupt, in texture as well as in color and structure. Lime usually occurs at or near the 50-cm depth, often accompanied by a salt horizon. Textures at these lower depths are usually silty clay loam in material that is moderately alkaline. Upper horizons are usually slightly acid to neutral.

This soil occurs quite extensively in Matzhiwin Plain, particularly in the part that lies east of Lake Newell. There, Wardlow is found in association with the Karlsbad and Tilley series. In the sandier portions of this area, Wardlow has been mapped in association with the Rolward and Rolling Hills series (Figure 29). In the general area between Brooks and Duchess, Wardlow occurs in scattered locations, mainly as the minor map unit component. Significant areas of Wardlow can be found between Rosemary and Gem and beyond to the north, where Karlsbad and Tilley, and to a lesser extent Chin, form the associated soils. In the portion of Kininvie Plain lying northwest of Lake Newell, Wardlow is found in association with the Duchess series, as well as the Karlsbad and Tilley series.

The solonetzic characteristics of Wardlow are the main limitation to its agricultural use. This is particularly true under irrigation because the saline subsoil may cause salinity problems.

Walsh series (map symbol Wl)

Extent 2790 ha (0.46% of total area)
Classification - Rego Gleysol
Usual surface texture - silty clay loam
Major associated series - Gleddies, Sterling
Parent material - fine clayey lacustrine
Associated landform - level and depressional
Slope range - 0-2%
Drainage - poorly drained
Agricultural capability - 5 w
Irrigation rating - poor
Grazing carrying capacity - 8-10 ha/AUY

The most striking feature of Walsh soil is the dull colors resulting from its poorly drained position in the landscape. It usually has a dark grayish brown A horizon 1-2 cm thick. This weakly structured and loose material has a silty clay loam texture and a neutral to mildly alkaline reaction. Below it, the C horizon is olive gray to dark olive gray with brownish mottles, and has a massive structure and a silty clay texture. Usually the C has a low lime content resulting in mildly to moderately alkaline pH values. Walsh soils are similar to Ventre soils, the main difference being the finer textures of the former.

Walsh soils are most widespread in Matzhiwin Plain, occurring mostly as isolated areas near or in association with lacustrine soils such as those near Millicent where several Walsh areas occur. However, in the poorly drained and saline area east of Tilley, Walsh is associated with the Gleddies series. Because several of the depressional areas within Kininvie Plain have been infilled with silty clay, they have been mapped as Walsh. This soil also occurs in some drainage channels within the county, the most notable area being near the northern end of Crawling Valley where Walsh and Gleddies were mapped together.

Because of its poorly drained position in the landscape, Walsh is unsuitable for both dryland and irrigated agriculture unless some form of drainage is provided. However, for grazing purposes this soil is among the best in the county.

Wainwright series (map symbol Wt)

Extent - 200 ha (0.03% of total area)
Classification - Orthic Dark Brown Chernozemic
Usual surface texture - loamy sand
Major associated series - Scollard
Parent material - sandy fluvial or eolian
Associated landform - undulating and ridged
Slope range - 2-15%
Drainage - rapidly drained
Agricultural capability - 4 m
Irrigation rating - fair
Grazing carrying capacity - 16-24 ha/AUY

The most obvious feature of Wainwright soil is its coarse texture. This soil has an Ah horizon 10-15 cm thick, dark grayish brown with a loose single grain structure. This structure continues into the darker brown B horizon, which is up to 20 cm thick and has a loamy sand texture. Colors gradually fade to pale brown in the C horizon, which is composed of very loose sand. Lime, if present in the lower C, is in very low concentrations. Neutral to mildly alkaline pH values in the A horizon gradually change to moderately alkaline in the C horizon. This soil is similar to the Cavendish soil described in the Appendix, the main difference being that Wainwright has a darker and thicker A horizon than that of the Cavendish profile.

Wainwright is found only in the western part of the County of Newell. It

was mapped in one main area toward the northern end of Crawling Valley, where it occurs as the minor map unit component in association with the Scollard series on a fluvial terrace formed in a wider portion of the valley. Smaller insignificant areas of this soil were also found in the sandy area above the banks of Bow River, southwest of Bassano.

The loose sandy nature of this soil makes it vulnerable to wind erosion, for which reason it is undesirable for dryland cultivated agriculture. Under irrigation, moist conditions can be maintained for longer periods reducing the wind erosion hazard.

Whitney series (map symbol Wy)

Extent - 1375 ha (0.22% of total area)
Classification - Orthic Dark Brown Chernozemic
Usual surface texture - silt loam
Major associated series - Hughendon, Flagstaff, Lethbridge
Parent material - fine loamy fluvial or lacustrine over till
Associated landform - level, undulating, and low-relief hummocky
Slope range - 0.5-9%
Drainage - well drained
Agricultural capability - 3 m
Irrigation rating - good
Grazing carrying capacity - 10-12 ha/AUY

The main characteristic of the Whitney soil is that it consists of an upper fluvial or lacustrine material and underlying till at less than 1 m. In this respect it resembles the Cranford series, its Brown Chernozemic counterpart, which is described in the Appendix. Whitney has a dark grayish brown Ah horizon, about 10-15 cm thick, with a fine granular to subangular blocky structure and a loam to silt loam texture. The B horizon, usually about 15 cm thick, is dark brown, friable prismatic silt loam. The color gradually changes to yellowish brown, which continues until the underlying brown till is reached usually at or near 50-60 cm. Above the clay loam till, textures are usually silt loam to silty clay loam with an abrupt boundary between the two materials. Although lime may occur in the upper material, it is most often present only in the underlying till. Neutral pH values prevail in the upper profile but become mildly alkaline in the lower portion of the overlay and moderately alkaline in the underlying till.

Whitney soils occur only on the western side of the county in low-relief areas of till. The lower portions of these areas were once inundated by waters that deposited a fluvial-lacustrine veneer of material on which the Whitney soil has now formed. This is illustrated in Figure 18, where Whitney occupies a similar landscape position to that of Cranford. Whitney is the minor map unit component in various combinations with the Hughendon, Flagstaff, or Lethbridge soils.

This soil generally has a relatively high rating for all agricultural uses. Under irrigation, lateral water movement may occur along the interface between the two materials, which could result in seepage.

Yarnley series (map symbol Yn)

Detailed information in Appendix
Extent - 4005 ha (0.65% of total area)
Classification - Brown Solodized Solonetz
Usual surface texture - loamy sand
Major associated series - Cavendish, Vendisant, Antelope
Parent material - sandy fluvial or eolian
Associated landform - level and undulating
Slope range - 0.5-5%
Drainage - rapidly drained
Agricultural capability - 5 md
Irrigation rating - non-irrigable
Grazing carrying capacity - 16-24 ha/AUY

The main distinguishing feature of Yarnley soil is the solonetzic profile developed in a sandy material. Loamy sand textures are common to all horizons, with only a very slight increase in clay content in the B horizon. Dark grayish brown colors continue well into the profile but become lighter in the C horizon. Throughout the profile the pH values are significantly higher than those of other Solonetzic soils in the county. Low concentrations of lime occur in the B horizon and below. The weak cementation in the C horizon becomes even more pronounced in locations where this horizon has been exposed and dried.

Yarnley soils, occurring only in Matzhiwin Plain, are concentrated in the sandy area between Rosemary and Red Deer River, where they occur intermittently as the minor component of the map unit. They are usually found in lower landscape positions. Smaller isolated areas of Yarnley occur elsewhere in Matzhiwin Plain, specifically around Patricia, in a small area north of Rolling Hills, and around San Francisco Lake.

Areas of Yarnley soil are best suited for grazing, despite their low carrying capacity. The coarse texture and associated wind erosion hazard rule out cultivation of this soil for either dryland or irrigated agriculture.

Youngstown series (map symbol Yt)

Extent - 2790 ha (0.45% of total area)
Classification - Brown Solodized Solonetz
Usual surface texture - sandy loam
Major associated series - Cavendish, Bingville, Yarnley
Parent material - coarse loamy fluvial
Associated landform - level and undulating
Slope range - 0.5-5%
Drainage - well drained
Agricultural capability - 4 md
Irrigation rating - poor
Grazing carrying capacity - 16-19 ha/AUY

Youngstown soil can be recognized by the Solodized Solonetz profile developed in sandy loam. The Ah horizon, about 20-30 cm thick, is brown to

dark brown sandy loam. It gradually merges into the grayish brown Ae horizon, which has a loamy sand texture and a loose single grain structure. There is an abrupt change into the Bnt horizon at about 35 cm below the surface. The weakly developed round-topped columns in this horizon are sometimes up to 15 cm wide. Sandy loam textures are usual in this dark yellowish brown material. The C horizon, occurring at 50-60 cm, is yellowish brown sandy loam. Lime is usually present in low to medium concentrations. It is common to encounter salts at these lower depths as well.

The limited areas of Youngstown occur almost exclusively in Matzhiwin Plain, primarily as the minor map unit component with other sandy soils. It is found in widely scattered areas, mainly in the southern part of the plain. Most of the Youngstown soils occur in the sandy areas west and north of Rosemary. Elsewhere in this plain, small amounts of Youngstown can be found around Patricia and on the east side of Lake Newell. Within Kininvie Plain, some Youngstown has been mapped in association with other sandy soils north of San Francisco Lake.

Generally, Youngstown soils have a low rating for agricultural production due to their sandy loam texture. Because of their solonetzic characteristics they are considered to have a marginal potential for irrigation.

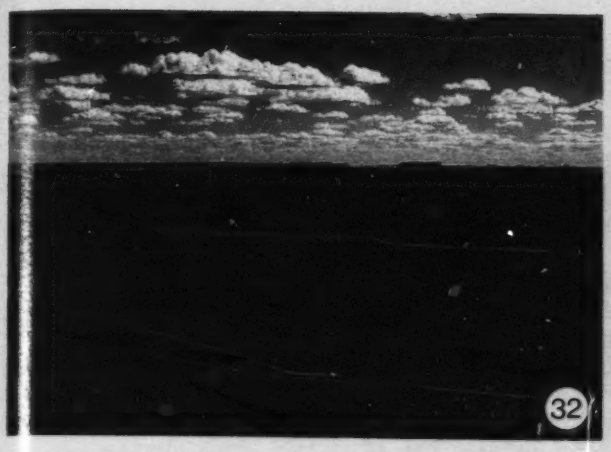
Rough Broken Land (map symbol RB)

In the County of Newell about 17 730 ha (28.91% of the total area) were mapped as rough broken land. As the name implies, this unit includes very rough and strongly eroded land which forms the banks along major stream channels, such as Red Deer and Bow rivers and their tributaries. The largest of these areas includes Dinosaur Provincial Park.

No attempt was made to differentiate soils in these rough broken areas because of their great complexity. However, most of the soils would probably belong to the Regosolic order. Topography is very complex with the majority of the slopes being very steep. Consequently, rough broken areas have no potential for agriculture other than a very low grazing capacity.

Disturbed Land (map symbol DL)

This unit, totaling about 1455 ha (0.22% of the total area), includes the larger urban areas such as the town of Brooks, as well as the largest areas disturbed by open-pit mining for either gravel or coal. One such area occurs in the valley of Bow River northwest of Rainier.



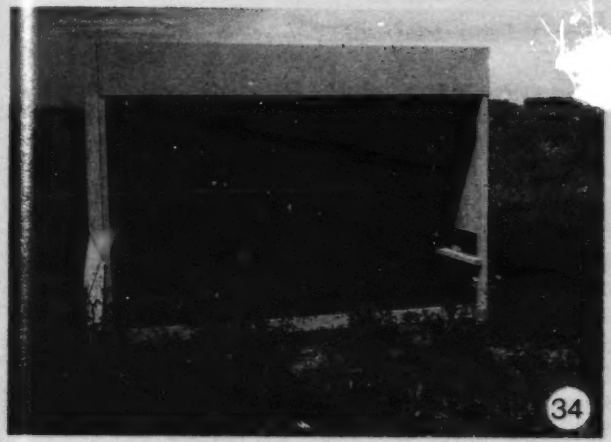


Figure 32. A Gleddies soil area. Note the red color of the samphire, a salt – tolerant plant.

Figure 33. Uneven crop pattern on a Hemaruka area.

Figure 34. Hives for leafcutter bees in the Tilley area.

Figure 35. Border dyke irrigation system.

Figure 36. Sprinkler irrigation using a center pivot system.

Figure 37. Salinity below a main canal.

# PART III. LAND USE AND INTERPRETATIONS

## THE EASTERN IRRIGATION DISTRICT[1]

The Eastern Irrigation District (EID) is the largest irrigation district in Alberta and is larger in area than the province of Prince Edward Island. This 600 000-ha tract of land was granted to the Canadian Pacific Railway by the Canadian government as part of the payment program for building the transcontinental railway, which was originally constructed through the area in 1883. In 1906, the CPR decided to build a dam across Bow River at Bassano to irrigate tracts of the semiarid prairie. Construction of the irrigation project started in 1910 and took four years to complete at a cost approaching $1.5 million.

Irrigation began in the spring of 1914 and the area started to fill up with settlers. The project cost the CPR $47 per irrigable acre, and land was sold to the farmers at $50 per acre. However, farm prices being what they were at that time, the farmers found they could not meet operating expenses and make payments on their purchase agreements. Consequently, there was a large annual turnover of settlers.

In 1935, after substantial consultation with farmer representatives, the CPR paid the farmers a large sum of money to take over the management of the project and in that year the province passed legislation to incorporate the Eastern Irrigation District, with headquarters at Brooks. Today some 1200 farmers operate the project comprising some 91 000 ha of irrigated land and about 400 000 ha of rangeland. The present distribution system consists of more than 1900 km of canals, 1600 km of surface drains, and more than 8000 control structures. Operation and management of the EID are carried out by a Manager, Board of Directors, and support staff. The Board of Directors is composed of farmers elected by other farmers in the district. The original Brooks aqueduct, completed in 1914 and long a landmark of the Brooks area, has recently been replaced by an earthfill structure of greater capacity (Fig. 38). Scheduled to be in operation by 1980, it has a capacity of 27 $m^3/s$.

Since irrigation first began in the Eastern Irrigation District, alfalfa has always been the most important crop in terms of area. This is still true today and over a quarter of the irrigated area is devoted to alfalfa hay. Much of this is utilized in the local livestock industry but a significant amount is sold outside the irrigated area. A pelleting plant at Brooks and a cubing plant at Tilley process alfalfa produced on a number of hectares each year into pellets and cubes, some of which are exported to Japan. Alfalfa hay yields an average of 7.5 t/ha. Seasonal consumptive use of water for alfalfa is about 635 mm, leaving a deficit of some 400 mm.

Barley and soft wheat are the second major crops in terms of production, comprising about 20 and 17% respectively of the total irrigated area. Barley yields average about 3750 kg/ha and the crop is produced principally for malting or local livestock consumption. Soft white spring wheat is a contract crop and is used to make pastry flour. Average yields are about 3400 kg/ha. Smaller areas are used to produce oats, flax, rapeseed, and rye also.

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[1] Prepared by D.A. Roll, Irrigation Specialist, Alberta Agriculture, Brooks, Alberta.

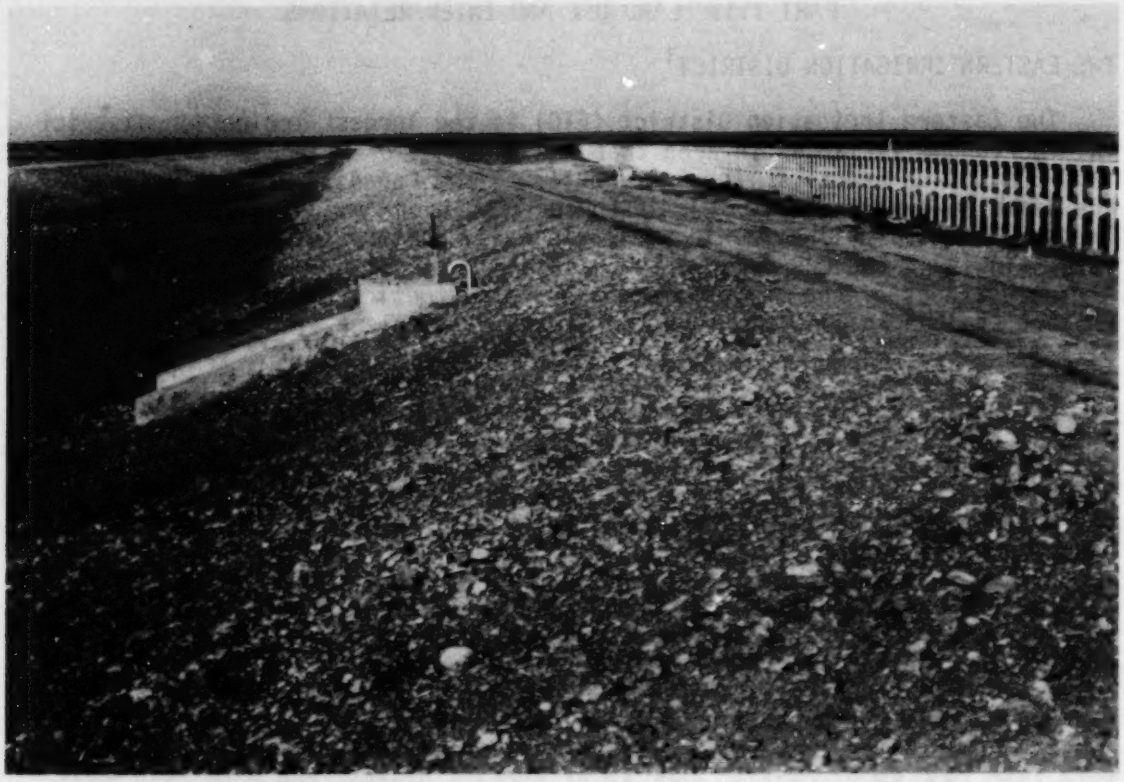

Figure 38. Earthfill canal structure replacing the Brooks aquaduct.

Specialty crops are produced on fewer hectares than the above crops but usually show a higher net return to their producers. They are usually grown in rotation with hay and cereal crops. These include potatoes, vegetables (carrots, corn, rutabagas, cabbage, beans, and parsnips), fruits (strawberry, etc.), dry beans, peas, sugar beets, alfalfa seed, and corn silage. These crops take up 8% of the irrigated area, with potatoes, alfalfa seed, and corn silage making up most of this.

Potatoes are produced for the fresh market, for processing, and for seed with yields averaging about 28 t/ha. The crop area has dropped over the past ten years. Today there are fewer growers but each grower uses a larger area. The bulk of potato production is in the Rainier, Rosemary, and Bassano districts.

Most of the other vegetable crops are marketed through the Newell Vegetable Co-op Ltd., at Brooks, which was established in 1969. These cooperatively owned facilities enable the producers to wash, grade, store, and ship their product for the fresh market. It is unlikely that the area of these crops will expand significantly in the near future without an additional market for them. Carrot yields in the Brooks area have averaged about 33 t/ha, with most being produced in the Rolling Hills district.

Beans, peas, and sugar beets are contract crops. Sugar beets have been produced only in the southern part of the district, in the Rolling Hills and Scandia areas, and the beets are shipped to Taber for processing. Average per-hectare yields of peas and sugar beets have been 5000 kg and 27 t, respectively.

Alfalfa seed is an important crop, since nearly two-thirds of all alfalfa seed produced in Canada at present is produced in the County of Newell. This seed is produced for domestic use and for export. The area used for alfalfa seed has been expanding and is now 1000-1300 ha, with seed yields averaging 280-340 kg/ha. Associated with seed production is an alfalfa leafcutter bee industry (color plate, Figure 34). Only through the use of leafcutter bees as pollinators can production of this crop be made worthwhile.

Corn silage has become an important crop with the development of center-pivot sprinkler systems and is produced for both on-farm use and as a contract crop for two large feedlot enterprises in the Brooks-Bassano area. Under good management, yields of up to 52 t/ha of 65% moisture silage have been obtained.

Honey production in the county exceeds 4500 kg annually by a half-dozen commercial producers.

Irrigation water is applied principally by border dyke (color plate, Figure 35) or border ditches, which are surface methods, or by sprinkler systems. Since the mid 1950's, nearly 20 000 ha of land have been machine-leveled for development of border-dyke systems and several hundred hectares continue to be leveled each year for this method of irrigation. Much of this leveling occurs on land which was previously irrigated but where undulating or irregular topography made it difficult to maintain efficient irrigation. A major portion of the alfalfa and cereal crops are irrigated by this method.

The use of sprinkler systems has increased dramatically in the past few years, and at present over a third of the irrigated area in the EID is irrigated by this method, using either wheel-move or center-pivot systems (color plate, Figure 36). More than 150 center-pivot systems are currently in use, mainly on specialized crops, such as corn, potatoes, vegetables, and high-value seed crops.

The availability of labor-saving pivot sprinkler systems has created a greater demand by farmers for the development of new land for irrigation within the district's boundaries, but some of this land is not ideally suited to irrigation.

Damage from salinity and seepage problems are becoming increasingly apparent in the EID (color plate, Figure 37). However, the actual extent of this has never been fully determined. A survey of some representative areas of the EID by Alberta Agriculture in 1966 estimated the amount of land that was potentially irrigable but was not actually irrigable due to seepage, salts, poor drainage, and high water tables. The percentages in the areas

investigated were: Rosemary - 16%, Patricia - 45%, Rainier - 27%, and South Bantry - 17%. Since that time these percentages have increased. These figures do not include land where salinity may slightly reduce yields of most crops or restrict the growing of salt-sensitive crops.

To date, reclamation of these lands and lining of canals and laterals to prevent seepage have been very limited. The costs of reclaiming farmland have been borne by the individual farmer, although the Irrigation District has funded canal-lining projects.

Farmers have installed subsurface plastic drainage systems on a few hundred hectares of farmland to date as a measure for reclaiming salt-affected areas. The cost of these systems has ranged from $700 to over $1500/ha and although there is considerable interest among farmers in reclamation, the costs discourage them from undertaking many of these projects on their own.

## IRRIGATION RATING

Figures obtained from the Eastern Irrigation District indicate that about 92 000 ha (about 15% of the total area) are being irrigated, as outlined in Figure 41. These irrigated lands lie almost entirely within Matzhiwin and Chin plains, where the combination of soil and topography is such that the area has been rated dominantly classes 1 and 2 for irrigation (Fig. 39). Irrigation is concentrated on the Chernozemic soil areas, with the exception of the Rosemary-Gem area and an area south of Millicent, where some Solonetzic soils are being irrigated. Unfortunately, a significant proportion of these better irrigation areas lie within irrigation subregion II (Figure 3), which reflects some limits on crop selection because of the lower heat units.

The irrigability of an area is determined by its soil and topography. Soil characteristics such as morphology, chemical composition, texture, depth of profile, parent material, salinity, stoniness, and erosion all influence how any given soil reacts to irrigation water. The degrees of influence these characteristics have on irrigation can be rated relative to one another, and the irrigability of soil can thus be determined. The Handbook for the Classification of Irrigated Land in the Prairie Provinces (8) outlines the rating of all soil characteristics for irrigation and establishes various irrigability classes. Using that system with some modifications, as well as the Alberta Standards for Irrigated Land Classification (1), all the soil series in the County of Newell have been rated for irrigation and placed in soil groupings (Table 8). The individual series rating is included on the legend for the soil maps accompanying this report. It must be emphasized that the irrigation rating for the individual soil series is preliminary only, and is based on accumulated performance data for various soils under irrigation. To determine the irrigability of the individual parcel of land, not only must the topography be considered but it also becomes necessary to collect and analyze soil samples for each parcel, which is beyond the scope of this soil survey. Nevertheless, the general irrigation potential of the county (Figure 39), so derived, may be helpful when considering irrigation expansion.

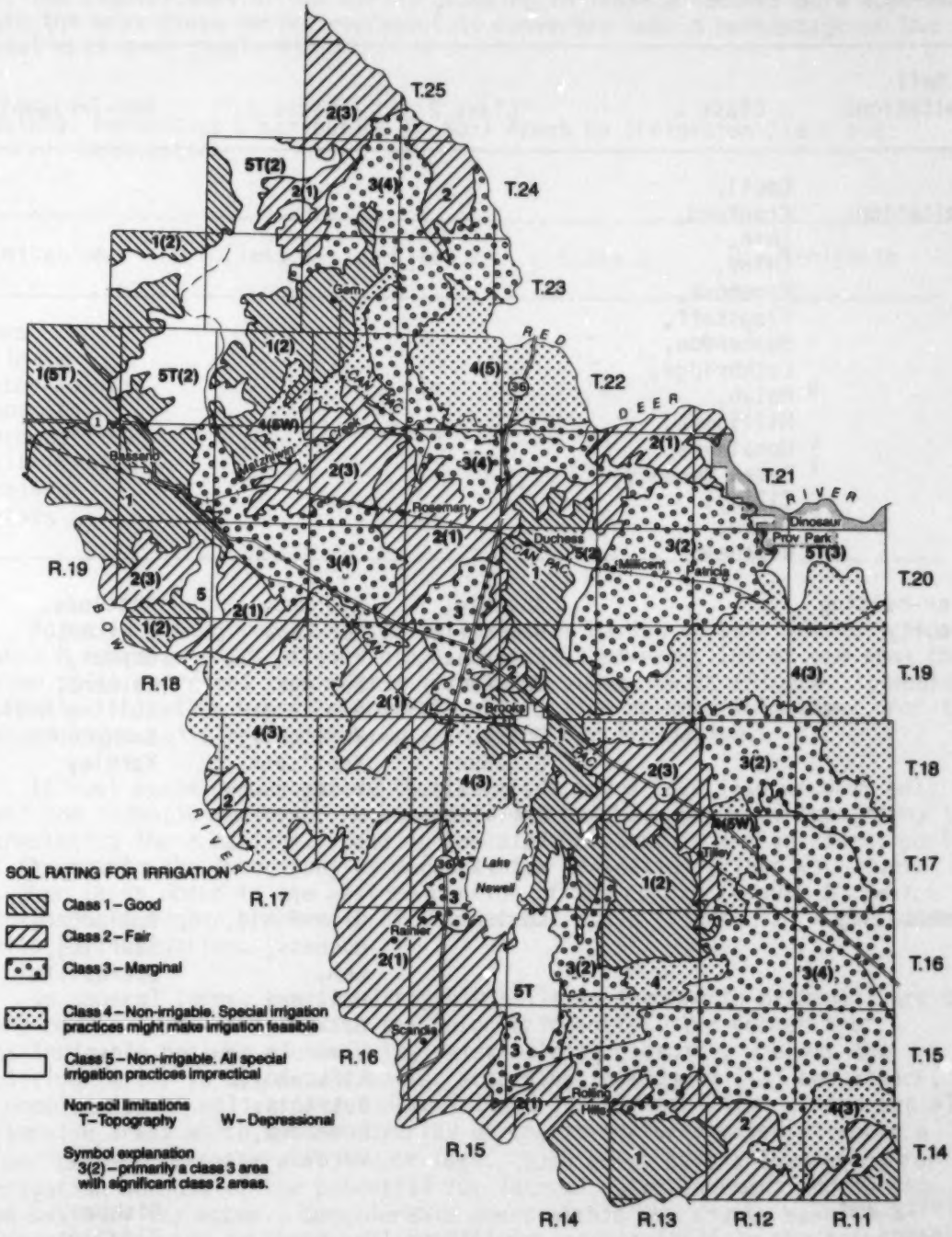


Figure 39. Generalized map of soil ratings for irrigation.

Table 8. Grouping of Soil Series into Irrigation Classes

| Soil limitations | Class 1 | Class 2 | Class 3 | Non-irrigable |
|---|---|---|---|---|
| No limitations | Cecil, Cranford, Chin, Chinz, Foremost, Flagstaff, Hughendon, Lethbridge, Maleb, Millicent, Ronalaine, Seven Persons, Tilley, Timko, Whitney | | | |
| Water-holding capacity | | Antonio, Bingville, Cavendish, Crowfoot, Chokio, Dolcy, Expanse, Helmsdale, Ramillies, Rainier, Wainright | Kangaroo, Pemukan, Purple, Springs, Scollard, Verdigris, Vendisant Youngstown | Antelope, Etzikom, Gopher, Rolward, Rolling Hills, Sunnynook, Yarnley |
| Permeability | | Karlsbad | Brownfield, Duchess, Gem, Halliday, Halkirk, Hemaruka, Kirkcaldy, Patricia, Rosemary, Wardlow | Bullpound, Sterling, Steveville |
| Salinity and drainage | | | | Dishpan, Gleddies, Illingworth, Islands, Kitsim, Scotfield, Ventre, Walsh |

The significance of the series grouping in Table 8 becomes more apparent when the area these series represent is converted into a percentage of the total soil area (Table 9).

Table 9. Percentage Distribution of Soil Areas by Irrigation Class and Limitation

| Limitation | Class 1 | Class 2 | Class 3 | Non-irrigable |
|---|---|---|---|---|
| None | 17 | - | - | - |
| Climate | - | 15 | - | - |
| Water-holding capacity | - | 18 | 4 | 6 |
| Permeability | - | 3 | 31 | 3 |
| Salinity and drainage | - | - | - | 3 |
| Totals | 17 | 36 | 35 | 12 |

Actually, the group of 16 series listed as having no soil limitations in Table 8 represents 32% of the total soil area. However, 15% of the area these Brown soils represent lies within irrigation subregion II (Figure 3), where a climatic limitation places a moderate restriction on crop selection. For this reason these soils are considered as class 2 for irrigation.

It must again be emphasized that Tables 8 and 9 take into account only the soil and climatic factors. No consideration has been given to topography in formulating these ratings. Data in Table 3 show that in a significant portion of the county the topography is marginal for irrigation (class 4). These rougher lands occur in the western portion of the county (Figure 8), which contains the higher proportion of Chernozemic soils (Figure 12) - the better soils for irrigation.

In general terms, the non-irrigable soils in the County of Newell are the very coarse textured soils and the Solonetzic soils. The former are non-irrigable because of their low water-holding capacity, whereas the limiting factor in Solonetzic soils, according to Krogman (13) and others, is a combination of saline parent material and low permeability. There are also extensive areas which have an overlay of coarse textured material above a finer textured material, at 1 m or less. Such areas have a low rating for irrigation because of the potential for lateral water movement and seepage, and salinity may occur. Considerable areas within the county have been adversely effected by these soil conditions, particularly in the Patricia locality.

With regard to irrigation expansion, some indication of the potential can be derived from the generalized irrigation rating map (Figure 39). Only soil and topographic factors were considered in generating this map, and no consideration was given to whether areas could be fed by gravity from the present canal system, or by pump lift. Although a considerable area of non-irrigated land lies below the main canals, much of it has limited potential for irrigation. The area between Gem and Red Deer River is undesirable because of its very sandy nature, as is the area between the Tilley and Rolling Hills districts. A fairly large area east of Tilley is also below the main canal; it has limited potential, however, because of the Solonetzic character of the soil. Probably the area with the most potential for irrigation expansion is north of Millicent where Solonetzic soils, although present, are less dominant than elsewhere.

Since a large proportion of the county lies above the present main canal system, any irrigation extension must be by pump lift. However, pump lifts must of economic necessity be kept to a minimum; thus, only a small proportion of the above-canal area has expansion potential. These above-canal soils generally have Solonetzic characteristics and are inferior for irrigation, particularly within the eastern and western portions of Kininvie Plain (Figure 5). One exception is an area between Scandia and Lake Newell, which generally has soils with fewer limitations to irrigation than elsewhere. By and large, Crawling Valley Upland is too high to make pump lift irrigation feasible.

## SALINITY

Wherever irrigation is practiced, some degree of salinity can be expected. In the Eastern Irrigation District, no accurate figure is currently available on damage by salinity, although some estimates have been made. D. A. Roll, in his account on "The Eastern Irrigation District," makes reference to an Alberta Agriculture survey in 1966 which gives estimates ranging from 16 to 45% of soils affected in various areas. Probably because the survey includes areas with poor drainage and high water tables, these estimates are considerably higher than ones made by the Alberta Soil Survey in 1954 (4) and 1955 (10) in the Tilley and Patricia-Millicent areas (Table 10). A comparison of these various estimates indicates that salinity is increasing.

Table 10. Percentage of Salt-affected Soils in the Tilley and Patricia-Millicent Areas

| | Tilley | Patricia-Millicent |
|---|---|---|
| Slightly affected (0.15-0.35% salts); growth of sensitive crops reduced | 7.0 | 4.6 |
| Moderately affected (0.35-0.65% salts); no crop does well | 6.0 | 9.2 |
| Strongly affected (>0.65% salts); few plants survive | 3.7 | 4.1 |
| Total affected | 16.7 | 17.9 |

Most salt-affected soils in the Eastern Irrigation District are found along and downslope from permanent canals (color plate, Figure 37), and in level to depressional areas where groundwater discharge often occurs (Fig. 40). There is also a greater occurrence of salinity in areas where sandy material overlies finer textured material. The situation is even more serious when the underlying material is derived from a saline deposit such as the Bearpaw formation (Figure 4). This is the situation in the Patricia-Millicent area, which has the highest percentage of land affected by salinity in the Eastern Irrigation District. A significant proportion of that area has a variable thickness of highly permeable loamy sand to sandy loam overlying a much less permeable clay loam till or soft rock in which a Solonetzic profile has often developed. As a result, irrigation water moves laterally above the less permeable material, surfacing downslope as seepage areas which are usually saline.

As Table 10 indicates, almost as high a percentage of the Tilley area is affected by salinity as in the Patricia-Millicent area. However, the damage is less severe, in large part because of the difference in soils. In the Tilley area soils are both finer textured and more uniform, and underlying materials are at greater depths and are less saline. Severe seepage areas are primarily found along main canals, many of which are slightly elevated to maintain a head of water for gravity irrigation in the relatively flat terrain of the Tilley area.

Figure 40. A saline groundwater discharge area.

## CAPABILITY FOR DRYLAND AGRICULTURE

By means of the Canada Land Inventory system (9), the agricultural capability of an area can be determined. This sytem uses seven classes based on the degree of limitation for agricultural use, the limitations becoming progressively greater from class 1 to class 7. Each class indicates the general suitability of the soils for agriculture; subclasses group soils with similar kinds of limitations for agricultural use. Using this system, soil capability maps were published by the Canada Land Inventory program for the Medicine Hat map sheet in 1968 (16) and the Gleichen map sheet in 1969 (11). These two maps cover all but the most northerly portion of the county, which is included in the Drumheller map sheet (15).

Fig. 41 is a generalized soil capability map for the county, derived from the soil map, using the Canada Land Inventory system. Each series is given a capability rating for agriculture based on limitations peculiar to that series. These capability ratings have been included with the legend for the soil maps accompanying this report. For convenience, the soil series mapped in the county have been grouped into classes and subclasses of similar limitations (Table 11). This in turn has been converted to percentages (Table 12), which indicate the extent of each capability class and subclass in the county. These figures do not include the topographic limitation associated with the various soils.

It is obvious from Table 12 that a large proportion (74%) of the county has a dryland agriculture capability of class 4. This is in large part due to the low annual precipitation in this area. As noted earlier in the discussion on climate, all but the extreme northwestern part of the county is in agroclimatic area 3A (Figure 3) and therefore has a severe moisture deficiency. This means that most soils with a surface texture ranging from sandy loam to loam will be rated as class 4 for dryland agriculture, according to the Canada Land Inventory guidelines (9). In agroclimatic area 3A, only soils with surface textures of clay loam or finer will be rated as class 3 because of their higher moisture-holding capacity. Most of the soils of medium texture in agroclimatic area 2A will be rated as class 3. Solonetzic soils, because of the hard structure and low permeability of the B horizon, are generally rated lower than the Chernozemic soils. Coarse textured soils with loamy sand and sand textures are rated no better than capability class 5 because of their low water-holding capacity and their vulnerability to wind erosion if cultivated (Fig. 42).

## GRAZING CAPABILITY

A significant portion of the county is being used for native grazing, primarily because of a low rating for both irrigation and dryland farming. These grazing areas are concentrated in Kininvie Plain, where soils are dominantly Solonetzic, and in the high-relief portions of Crawling Valley Upland. Grazing is also the dominant land use in the very sandy and erosion-sensitive areas of Matzhiwin Plain (Fig. 43).

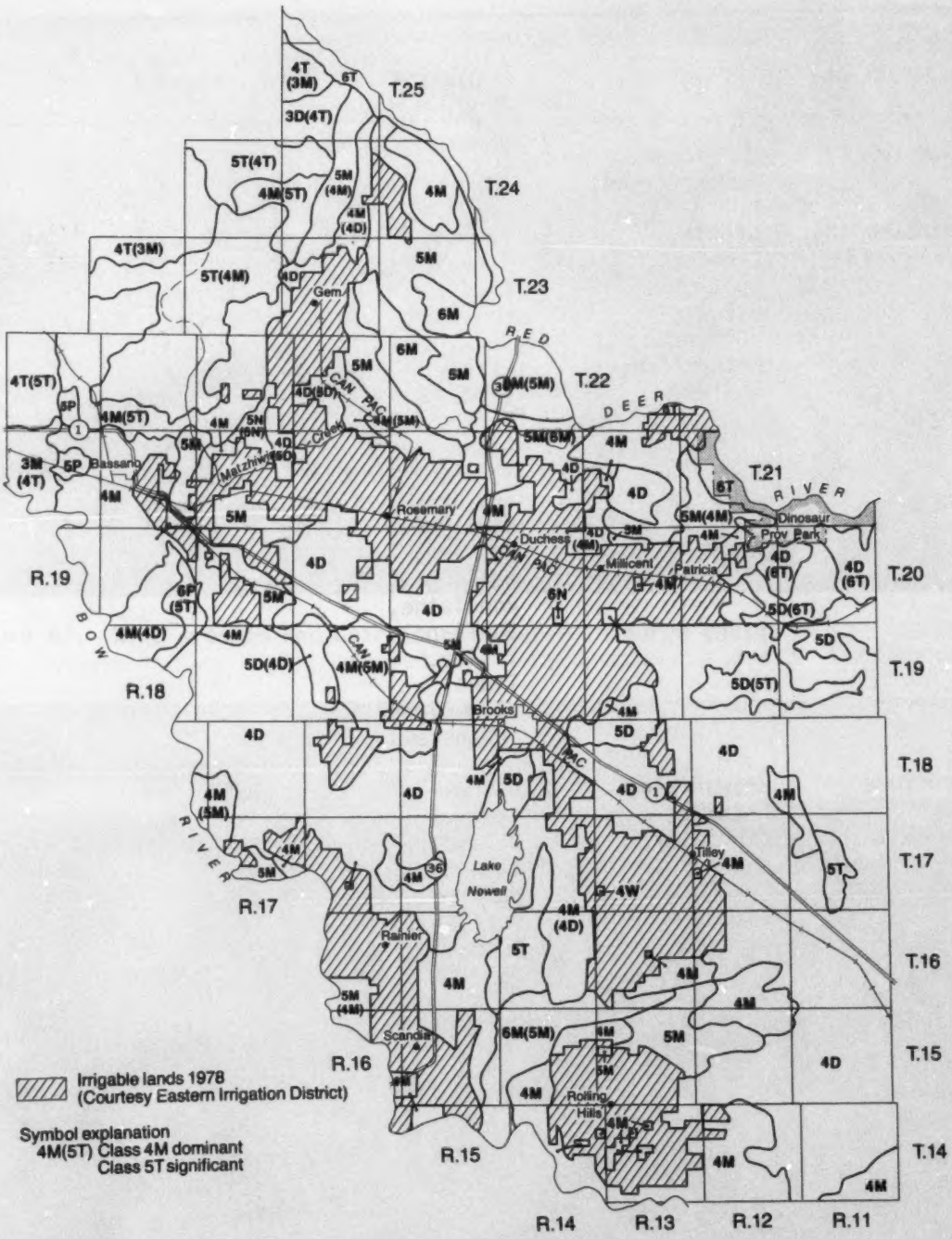


Figure 41. Generalized map of soil capabilities for agriculture.

Table 11. Grouping of Soil Series into Agricultural Capability Classes

| Subclass (limitation) | Class 3 | Class 4 | Class 5 | Class 6 |
|---|---|---|---|---|
| Climate (C) | Millicent, Seven Persons | | | |
| Moisture (M) | Chokio, Crowfoot, Dolcy, Flagstaff, Hughendon, Lethbridge, Whitney | Antonio, Bingville, Cecil, Cranford, Chin, Chinz, Expanse, Foremost, Gopher, Maleb, Rainier, Ramillies, Rolward, Rolling Hills, Ronalaine, Scollard, Tilley, Timko, Wainwright, Youngstown | Cavendish, Helmsdale, Kangaroo, Purple, Springs, Pemukan, Sunnynook, Verdigris, Vendisant, Yarnley | Antelope, Etzikom |
| Structure and/or permeability (D) | Brownfield, Halkirk, Kirkcaldy | Duchess, Gem, Halliday, Hemaruka, Karlsbad, Patricia, Rosemary, Wardlow | Bullpound, Sterling, Steveville | |
| Salinity (N) | | | | Dishpan, Gleddies, Kitsim, Scotfield |
| Excess water (W) | | | Islands, Illingworth, Ventre, Walsh | |

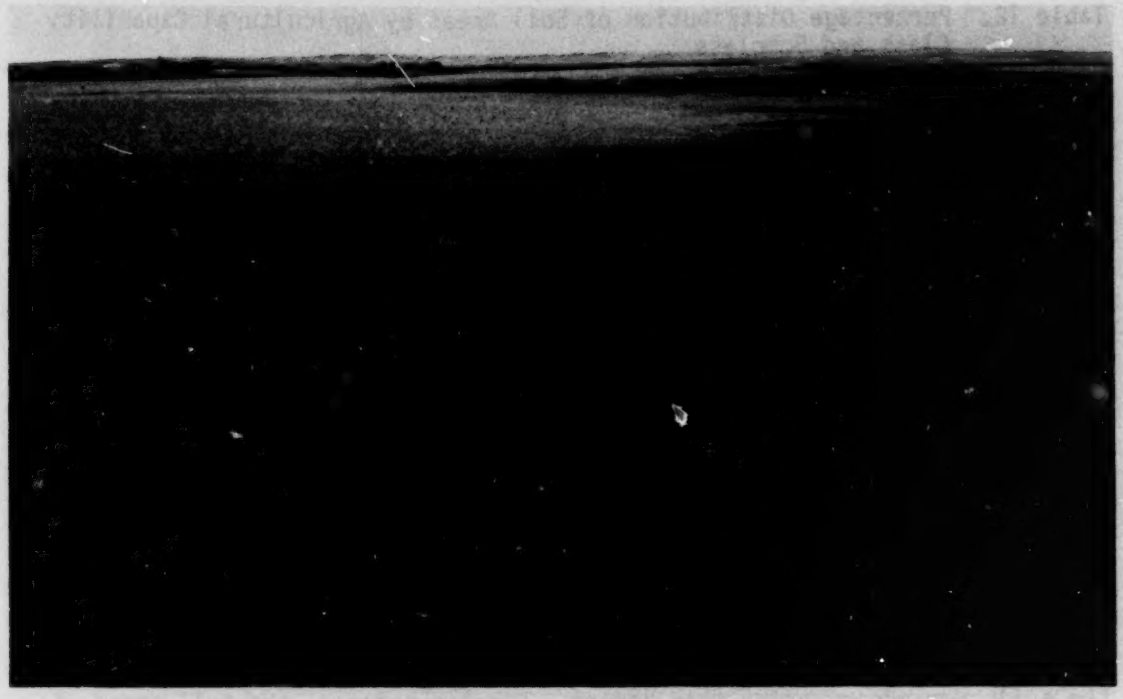

Figure 42. Wind erosion and drifting on coarse textured soils.

Figure 43. Native pasture on sandy fluvial-eolian areas.

Table 12. Percentage Distribution of Soil Areas by Agricultural Capability Class and Subclass

| Subclass (limitation) | Class 3 | Class 4 | Class 5 | Class 6 |
|---|---|---|---|---|
| Climate (C) | 2 | - | - | - |
| Moisture (M) | 3 | 40 | 12 | 2 |
| Structure and/or permeability (D) | 1 | 34 | 3 | - |
| Salinity (N) | - | - | - | 2 |
| Excess water (W) | - | - | 1 | - |
| Totals | 6 | 74 | 16 | 4 |

Because of the similarity in soils and climate between this area and that covered by the Oyen map sheet report (12) to the north, similar carrying capacities can be expected on soil series that occur in both areas. Using data from that report, as well as procedures outlined in the Guide to Range Condition and Stocking Rates for Alberta (21), the estimated carrying capacity for each soil series was determined. These estimates appear on the legend for the soils map accompanying this report. For convenience, the full range of carrying capacities for this area has been arbitrarily divided into six groups, and each soil series placed in a group based on its estimated carrying capacity. The total land area in each group is shown in Table 13.

Table 13. Areal Extent of each Carrying Capacity Group

| Group | Carrying capacity (ha/AUY) | Area (ha) | Percentage of total |
|---|---|---|---|
| 1 | 8-10 | 6 000 | 1 |
| 2 | 10-12 | 18 000 | 3 |
| 3 | 12-16 | 268 000 | 46 |
| 4 | 16-24 | 195 000 | 34 |
| 5 | 24-49 | 84 000 | 15 |
| 6 | >49 | 6 000 | 1 |

No attempt has been made to determine actual range conditions, but the carrying capacity for each series is based on good range conditions where the more desirable native grass species are dominant over the less desirable invader species. Thus, the areas outlined in Fig. 44 reflect only grazing

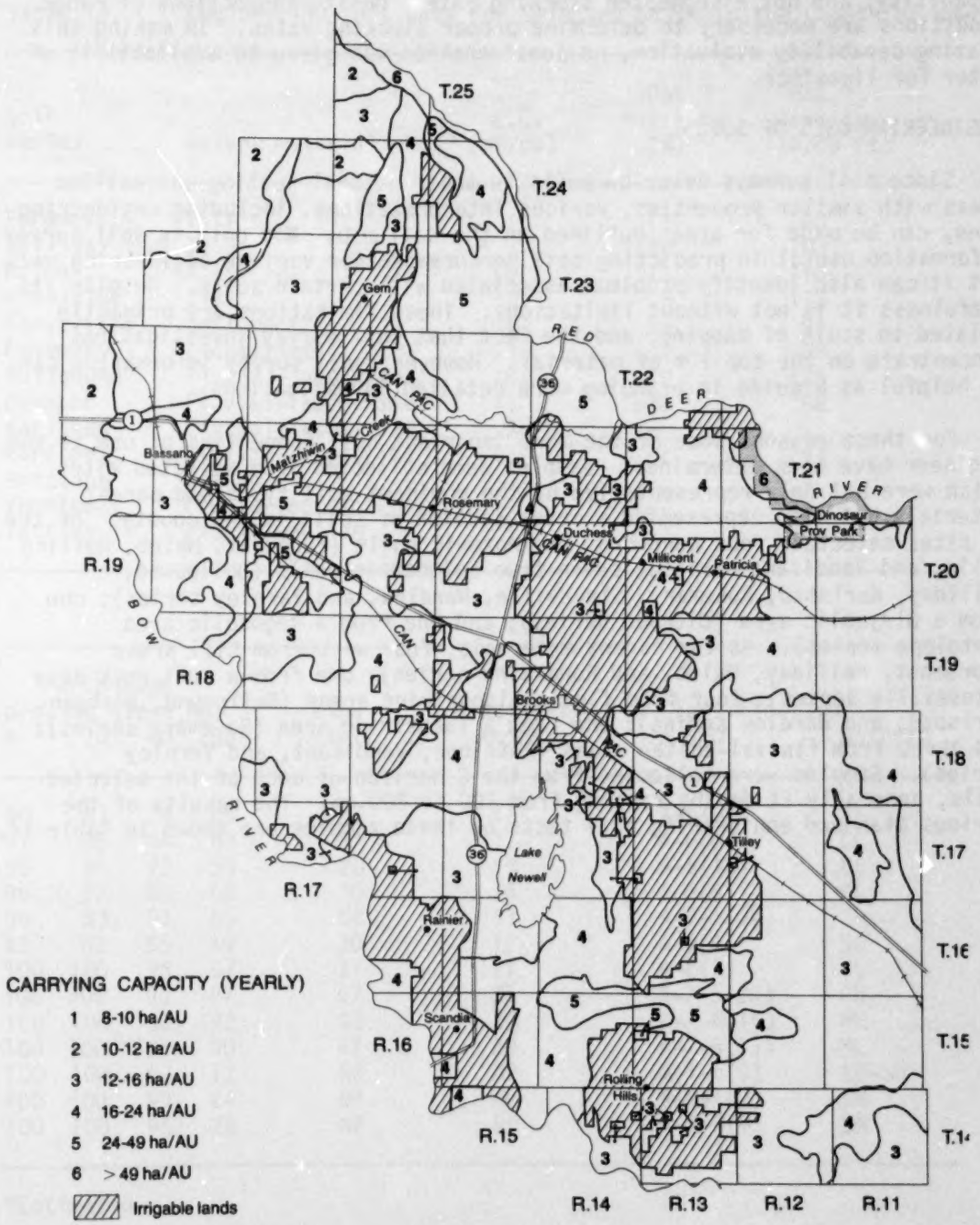


Figure 44. Generalized map of grazing capabilities.

capability, and not a suggested stocking rate. Onsite inspections of range conditions are necessary to determine proper stocking rates. In making this grazing capability evaluation, no consideration was given to availability of water for livestock.

## ENGINEERING USES OF SOILS

Since soil surveys describe soils in their natural setting and outline areas with similar properties, various interpretations, including engineering uses, can be made for areas outlined on the soil map. Not only is soil survey information useful in predicting soil performance for various engineering uses but it can also identify problems associated with certain soils. Despite its usefulness it is not without limitations. These limitations are primarily related to scale of mapping, and the fact that soil survey investigations concentrate on the top 1 m of material. However, soil survey information can be helpful as a guide in planning more detailed investigations.

For these reasons some of the more important soil properties of use to the engineer have been determined. Samples were collected from selected sites which were not only representative of the dominant soil types and parent materials but also represented a cross section of soils in the county. Of the 13 sites selected, four were from Chernozemic soils (Foremost, Maleb, Rolling Hills, and Vendisant series); seven from Solonetzic soils (Bullpound, Halliday, Karlsbad, Rosemary, Steveville, Wardlow, and Yarnley series); one from a Gleysolic area (Dishpan series); and one from a Regosolic area (Antelope series). As for parent materials, four were from till areas (Foremost, Halliday, Maleb, and Ronalaine series); one from a soft rock area (Steveville series); four from fluvial-lacustrine areas (Bullpound, Dishpan, Karlsbad, and Wardlow series); one from a lacustrine area (Rosemary series); and three from fluvial-eolian areas (Antelope, Vendisant, and Yarnley series). Samples were collected from the C horizon of each of the selected soils, generally at depths ranging from 100 to 200 cm. The results of the various standard engineering soil tests on these samples are shown in Table 14.

Table 14. Engineering Test Data for Selected Soils in the County of Newell

| Soil series | Parent material | E.C. (mS/cm) | Opt.* moisture (%) | Max.* density (lb/cu ft) | Percentage passing sieve No. 4 | 10 | 40 | 200 | Liquid limit | Plasticity index | Classification AASHO | Unified |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Foremost | Till | 7 | 13 | 120 | 90 | 87 | 74 | 55 | 27 | 13 | A-6(5) | CL |
| Halliday | Till | 3 | 20 | 103 | 97 | 95 | 84 | 63 | 37 | 17 | A-6(8) | CL |
| Maleb | Till | 10 | 13 | 118 | 95 | 91 | 77 | 53 | 28 | 13 | A-6(15) | CL |
| Ronalaine | Till | 10 | 15 | 113 | 96 | 92 | 80 | 58 | 30 | 14 | A-6(6) | CL |
| Steveville | Soft rock | 14 | 29 | 91 | 96 | 93 | 91 | 85 | 58 | 31 | A-7-6(20) | CH |
| Rosemary | Lacustrine | >1 | 17 | 108 | 73 | 62 | 55 | 49 | 30 | 12 | A-6(4) | SC |
| Bullpound | Fluvial-lacustrine | 5 | 10 | 125 | 100 | 100 | 96 | 57 | 27 | 17 | A-6(7) | CL |
| Dishpan | Fluvial-lacustrine | 11 | >30 | 88 | 100 | 100 | 95 | 87 | 67 | 35 | A-7-5(20) | CH |
| Karlsbad | Fluvial-lacustrine | 9 | - | - | 100 | 100 | 90 | 72 | 52 | 23 | A-7-6(16) | MH |
| Wardlow | Fluvial-lacustrine | 12 | 22 | 91 | 100 | 100 | 95 | 90 | 47 | 20 | A-7-6(13) | ML |
| Antelope | Eolian | - | - | - | 100 | 100 | 57 | 12 | NP | NP | A-1-6(0) | SP-SM |
| Vendisant | Fluvial-eolian | - | - | - | 100 | 100 | 99 | 24 | NP | NP | A-2-4(0) | SM |
| Yarnley | Fluvial-eolian | 1 | - | - | 100 | 100 | 96 | 26 | NP | NP | A-2-4(0) | SM |

*Estimated.

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# APPENDIXES

## APPENDIX A. ANALYTICAL METHODS

Most chemical and physical analyses were determined by the methods outlined by McKeague (14), except for the $CaCO_3$ equivalent which was determined using the method of Schollenberger (20). These results are presented on the following pages as part of the soil profile characterization. In addition, certain physical analyses were conducted to determine the general engineering properties of the soils in the County of Newell. The AASHO and Unified classifications are based on the method outlined in the PCA soil primer (18). Optimum moisture and maximum density were based on the correlation method outlined by Ring and Sallberg (19), using the monograph charts developed by the Highways Laboratory, Alberta Transport. Results from these engineering tests have been included in the engineering section.

It is important to know the chemical and physical properties of soil, because they are basic to soil classification and are also an indication of the soil's performance capabilities. Following are some brief comments relative to the significance of the analyses conducted.

### Reaction (pH)

Reaction is a measure of the intensity of soil acidity or alkalinity, which reflects the base status of the soil.

### Nitrogen (N)

Nitrogen is an important plant nutrient which is usually concentrated in the A horizon of soils in the form of decomposed organic matter. Nitrogen content can be directly related to the amount of organic matter and therefore to soil colors in the Ah horizon; darker Ah horizons have a higher nitrogen content than do lighter Ah horizons.

### Organic carbon (O.C.)

Organic carbon provides an estimate of organic matter content in the soil.

### Total exchange capacity (T.E.C. or C.E.C.)

The cation exchange capacity is important in the fertility of a soil. This capacity increases with increased clay and organic matter content and is lower in sandy soils. A criterion used in the classification of Solonetzic soils is the ratio of exchangeable calcium to exchangeable sodium: soils of the Solonetzic order must have a ratio of 10 or less.

### Calcium carbonate equivalent

The calcium carbonate equivalent is a measure of the lime carbonate content of a soil.

Particle size distribution

Particle size distribution is a determination of the relative amounts of sand, silt, and clay in a soil.

Electrical conductivity (E.C.)

Electrical conductivity is an indication of the amount of soluble salts in the soil.

Sodium adsorption ratio (S.A.R.)

Sodium adsorption ratio expresses the relative activity of sodium ions in exchange reactions with soil. It is used in rating the irrigability of soils. Lower values are desirable.

Available moisture

Available moisture is defined as the portion of soil moisture than can readily be absorbed by plant roots.

# APPENDIX B. DETAILED SOIL SERIES INFORMATION

## ANTONIO SERIES

Location: SW1, Twp 15, Rge 15, W4
Classification: Orthic Brown Chernozemic
Parent material: Coarse loamy fluvial veneer over till

| Horizon | Depth cm | |
|---|---|---|
| Ah1 | 0-3 | Dark grayish brown (10YR 4/2 m), brown (10YR 5/3 d); sandy loam; very weak, coarse prismatic, breaking to single grain; slightly sticky; very friable, nonplastic; plentiful, fine, random roots; abrupt, smooth boundary; 2-4 cm thick; mildly alkaline |
| Ah2 | 3-16 | Brown to dark brown (10YR 4/3 m), brown (10YR 5/3 d); sandy loam; weak to moderate, medium to coarse, subangular blocky; nonsticky; loose; nonplastic; plentiful, very fine, vertical roots; gradual, wavy boundary; 11-13 cm thick; mildly alkaline. |
| Bm1 | 16-36 | Brown to dark brown (10YR 4/3 m), dark brown to brown (10YR 4/3-5/3 d); sandy loam; weak, medium to coarse, subangular blocky; nonsticky; loose; nonplastic; few, very fine, vertical roots; gradual, wavy boundary; 20-21 cm thick; mildly alkaline. |
| Bm2 | 36-55 | Dark yellowish brown (10YR 4/4 m, d); sandy loam; very weak, medium, subangular blocky; nonsticky; very friable; nonplastic; few, very fine, vertical roots; abrupt, wavy boundary; 16-20 cm thick; mildly alkaline. |
| IICk | 55+ | Dark yellowish brown to yellowish brown (10YR 4.5/4 m), dark yellowish brown (10YR 4/6 d); clay loam; moderate, medium to coarse, subangular blocky; sticky; friable; slightly plastic; very few, very fine, vertical roots; moderate effervescence; moderately alkaline. |

| Hor. | Depth cm | pH ($H_2O$) | % N | % O.C. | Exchangeable cations meq/100 g Na | K | Ca | Mg | T.E.C. meq/100 g | Ca/Na ratio | % $CaCO_3$ equiv | Particle size % sand | % silt | % clay | Text. | E.C. mS/cm | S.A.R. | Est. avail. moist. cm/cm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ah1 | 0-3 | 7.5 | 0.2 | 2.1 | tr | 0.8 | 12.8 | 2.4 | 25.0 | - | 0.3 | 54 | 32 | 14 | FSL | - | - | 0.10 |
| Ah2 | 3-16 | 7.4 | 0.1 | 1.0 | tr | 0.6 | 8.8 | 2.0 | 18.3 | - | 0.2 | 59 | 28 | 13 | FSL | - | - | 0.06 |
| Bm1 | 16-36 | 7.7 | tr | 0.4 | - | - | - | - | - | - | 0.2 | 77 | 13 | 10 | SL | - | - | 0.04 |
| Bm2 | 36-55 | 7.7 | tr | 0.2 | - | - | - | - | - | - | 0.2 | 73 | 16 | 11 | FSL | - | - | 0.04 |
| IICk | 55+ | 7.9 | - | - | - | - | - | - | - | - | 10.8 | 21 | 51 | 28 | CL | - | - | 0.11 |

## ANTELOPE SERIES

Location: SW8, Twp 23, Rge 13, W4
Classification: Orthic Regosol
Parent material: Eolian

Horizon Depth cm

Ah 0-2 Dark brown (10YR 3/3 m), brown to dark brown (10YR 4/3 d); sand; single grain; loose; abundant, medium to fine, random roots; abrupt, smooth boundary; 0-5 cm thick; slightly acid.

C1 2-38 Brown to dark brown (10YR 5/3 m), brown (10YR 5/3 d); sand; single grain; loose; abundant, fine and very fine, vertical roots; diffuse, smooth boundary; 25-45 cm thick; neutral.

C2 38-122 Yellowish brown (10YR 5/4 d), dark yellowish brown (10YR 4/4 m); sand; single grain; loose; few, very fine, vertical roots; diffuse, smooth boundary; 51-91 cm thick; neutral.

C3 122-244+ Brown (10YR 5/3 d, 4/3 m); sand; single grain; loose; very few, very fine, vertical roots; mildly alkaline.

| | | | | | Exchangeable cations meq/100 g | | | | | | | Particle size | | | | | | Est. avail. moist. cm/cm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hor. | Depth cm | pH ($H_2O$) | % N | % O.C. | Na | K | Ca | Mg | T.E.C. meq/100 g | Ca/Na ratio | % $CaCO_3$ equiv. | % sand | % silt | % clay | Text. | E.C. mS/cm | S.A.R. | |
| Ah | 0-2 | 6.2 | 0.1 | 0.8 | 0.5 | 6.2 | 37.1 | 10.9 | 4.2 | 78 | - | 93 | 4 | 3 | S | - | - | - |
| C1 | 2-38 | 6.9 | - | - | 0.0 | 5.9 | 50.6 | 18.2 | 3.4 | - | - | 95 | 2 | 3 | S | - | - | - |
| C2 | 38-122 | 7.3 | - | - | 0.4 | 5.9 | 46.3 | 18.9 | 2.7 | 12 | 0.2 | 96 | 1 | 3 | S | - | - | - |
| C3 | 122-244 | 7.9 | - | - | 2.4 | 4.6 | 47.6 | 17.8 | 4.6 | 19 | 0.3 | 94 | 3 | 3 | S | - | - | - |

## BINGVILLE SERIES

Location: SW22, Twp 23, Rge 16, W4
Classification: Orthic Brown Chernozemic (irrigated)
Parent material: Coarse loamy fluvial

Horizon Depth cm

Ah1 0-5 Dark brown (10YR 3/3 m), dark grayish brown (10YR 4/2 d); sandy loam; compound, very weak, coarse prismatic, and single grain; loose; nonplastic; plentiful, fine and very fine, random roots; abrupt, smooth boundary; 2-6 cm thick; neutral.

Ah2 5-11 Dark yellowish brown (10YR 3/4 m), brown to dark brown (10YR 4/3 d); loamy sand to sandy loam; single grain; very friable; nonplastic; plentiful, very fine, vertical roots; gradual, wavy boundary; 4-8 cm thick; slightly acid.

| | | |
|---|---|---|
| Ah3 | 11-18 | Dark brown (10YR 3/3 m), brown to dark brown (10YR 4/3 d); loamy sand to sandy loam; compound, weak, medium, angular blocky, and single grain; very friable; nonplastic; plentiful, very fine, vertical roots; gradual, wavy boundary; 0-9 cm thick; slightly acid. |
| Btj | 18-34 | Dark yellowish brown (10YR 4/4 m, d); sandy loam; compound, weak, medium prismatic, and weak, medium, subangular blocky; friable; slightly plastic; few, very fine, vertical roots; diffuse, wavy boundary; 10-18 cm thick; slightly acid. |
| BC | 34-64 | Dark yellowish brown (10YR 4/4 m), yellowish brown (10YR 5/4 d); sandy loam; compound, weak, medium, subangular blocky, and very fine, single grain; very friable; nonplastic; few, very fine, vertical roots; clear, wavy boundary; 15-34 cm thick; neutral. |
| Cca | 64-89 | Light brownish gray (10YR 6/2 m), pale brown (10YR 6/3 d); sandy loam; compound, weak massive, and very fine, single grain; friable; very few, very fine, vertical roots; weak effervescence; gradual, wavy boundary; 18-28 cm thick; mildly alkaline. |
| Ck | 89+ | Light brownish gray (10YR 6/2 m), light gray (10YR 7/2 d); sandy loam; compound, weak massive, and very fine, single grain; very friable; very weak effervescence; moderately alkaline. |

| Hor. | Depth cm | pH ($H_2O$) | % N | % O.C. | Exchangeable cations meq/100 g Na | K | Ca | Mg | T.E.C. meq/100 g | Ca/Na ratio | % $CaCO_3$ equiv. | Particle size % sand | % silt | % clay | Text. | E.C. mS/cm | S.A.R. | Est. avail. moist. cm/cm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ah1 | 0-5 | 7.1 | 0.2 | 2.1 | 0.1 | 0.6 | 10.6 | 3.0 | 13.8 | 106 | - | 70 | 20 | 10 | SL | - | - | - |
| Ah2 | 5-11 | 6.5 | 0.1 | 0.9 | 0.2 | 0.6 | 9.9 | 0.8 | 11.0 | 50 | - | 79 | 13 | 8 | LS | - | - | - |
| Ah3 | 11-18 | 6.2 | 0.1 | 0.8 | 0.1 | 0.4 | 9.6 | 2.3 | 11.1 | 96 | - | 76 | 20 | 4 | LS | - | - | - |
| Btj | 18-34 | 6.4 | 0.1 | 0.6 | 0.2 | 0.4 | 12.9 | 2.9 | 15.0 | 65 | - | 71 | 21 | 8 | SL | - | - | - |
| BC | 34-64 | 6.7 | 0.1 | 0.5 | 0.2 | 0.4 | 9.9 | 5.3 | 13.2 | 50 | - | 70 | 19 | 11 | SL | - | - | - |
| Cca | 64-89 | 7.8 | - | - | - | - | - | - | - | - | 12.2 | 68 | 14 | 18 | SL | <1 | - | - |
| Ck | 89+ | 8.2 | - | - | - | - | - | - | - | - | 9.6 | 68 | 19 | 13 | SL | <1 | - | - |

CECIL SERIES

Location: SW28, Twp 16, Rge 11, W4
Classification: Solonetzic Brown Chernozemic (formerly Eluviated Brown Chernozemic)
Parent material: Till

| Horizon | Depth cm | |
|---|---|---|
| Ah | 0-14 | Brown to dark brown (10YR 4/3 m), brown (10YR 5/3 d); loam; weak, fine granular; very friable; abundant, fine, random roots; few, fine pores; clear, smooth boundary; 8-15 cm thick; mildly alkaline. |

Ae 14-20 Brown to dark brown (10YR 4/3 m), grayish brown to light brownish gray (10YR 5/2-6/2 d); loam; moderate, fine platy; very friable; plentiful, fine, random roots; common, fine, vesicular pores; abrupt, smooth boundary; 2-10 cm thick; neutral.

Bt 20-29 Brown to dark brown (10YR 4/3 d); loam to clay loam; moderate, fine, subangular blocky; slightly hard; plentiful, fine, inped and exped, vertical roots; clear, smooth boundary; 8-20 cm thick; mildly alkaline.

Cca 29-46 Brown (10YR 5/3 d); loam to clay loam; weak, medium, subangular blocky; hard; plentiful, fine, vertical roots; few pores; moderate effervescence; abrupt, smooth boundary; 17-50 cm thick; moderately alkaline.

Ck 46-96 Brown to dark brown (10YR 4/3 d); loam to clay loam; moderate, medium, subangular blocky; hard; plentiful, fine, vertical roots; contains $CaCO_3$ blotches, stones, coal flecks and ironstone flecks; weak effervescence; clear, smooth boundary; 25-52 cm thick; moderately alkaline.

Csk 96-100 Dark brown (10YR 3/3 d); clay loam; massive; slightly hard; few, fine vertical roots; contains $CaCO_3$ blotches, small stones, coal and iron-stone flecks; weak effervescence; mildly alkaline.

| Hor. | Depth cm | pH ($H_2O$) | % N | % O.C. | Exchangeable cations meq/100 g Na | K | Ca | Mg | T.E.C. meq/100 g | Ca/Na ratio | % $CaCO_3$ equiv. | Particle size % sand | % silt | % clay | Text. | E.C. mS/cm | S.A.R. | Est. avail. moist. cm/cm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ah | 0-14 | 7.4 | 0.1 | 1.2 | 0.1 | 1.2 | 6.9 | 2.5 | 7.5 | 138 | 0.4 | 44 | 43 | 13 | L | - | - | 0.09 |
| Ae | 14-20 | 7.2 | 0.1 | 0.8 | 0.2 | 0.7 | 7.4 | 2.9 | 8.8 | 34 | 0.4 | 40 | 38 | 22 | L | - | - | 0.10 |
| Bt | 20-29 | 7.5 | 0.1 | 0.8 | 1.2 | 1.3 | 25.3 | 9.2 | 9.2 | 21 | 0.1 | 38 | 36 | 26 | L | - | - | 0.12 |
| | | | | | Soluble salts meq/L | | | | | | | | | | | | | |
| Cca | 29-46 | 7.9 | - | - | 1.8 | 0.3 | 8.5 | | - | - | 7.4 | 37 | 37 | 26 | L | <1 | 1 | - |
| Ck | 46-96 | 8.2 | - | - | 5.7 | 0.1 | 1.5 | | - | - | 5.0 | 32 | 40 | 28 | CL | <1 | 7 | - |
| Csk | 96-100 | 7.7 | - | - | 55.4 | 0.6 | 45.5 | | - | - | 2.6 | 28 | 42 | 30 | CL | 6 | 12 | - |

## CAVENDISH SERIES

Location: SE14, Twp 21, Rge 17, W4
Classification: Orthic Brown Chernozemic
Parent Material: Sandy fluvial or eolian

Horizon Depth cm

Ah 0-23 Dark brown (10YR 3/3 m), dark grayish brown (10YR 4/2 d); loamy sand; single grain; very friable; plentiful, medium, fine, and very fine, random roots in upper portion, becoming fine and very fine, vertical in lower portion; clear, smooth boundary; 14-26 cm thick; slightly acid.

| | | |
|---|---|---|
| Bm | 23-61 | Dark brown to brown (10YR 4/3 m), brown (10YR 5/3 d); sand; single grain; very friable; plentiful, fine and very fine, vertical roots; gradual, wavy boundary; 25-45 cm thick; neutral. |
| C | 61-76+ | Dark yellowish brown to yellowish brown (10YR 4/4-5/4 m), brown to pale brown (10YR 5/3-6/3 d); sand; single grain; loose; few, very fine, vertical roots; neutral. |

| Hor. | Depth cm | pH ($H_2O$) | % N | % O.C. | Exchangeable cations meq/100 g Na | K | Ca | Mg | T.E.C. meq/100 g | Ca/Na ratio | % $CaCO_3$ equiv. | Particle size % sand | % silt | % clay | Text. | E.C. mS/cm | S.A.R. | Est. avail. moist. cm/cm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ah | 0-23 | 6.5 | 0.1 | 0.8 | 0.0 | 0.7 | 6.2 | 0.2 | 8.1 | - | - | 87 | 5 | 8 | LS | - | - | - |
| Bm | 23-61 | 6.9 | tr | 0.3 | 0.1 | 0.7 | 5.8 | 0.0 | 6.3 | 58 | - | 91 | 2 | 7 | S | - | - | - |
| C | 61-76+ | 7.3 | - | - | - | - | - | - | - | - | 0.0 | 92 | 2 | 6 | S | - | - | - |

CRANFORD SERIES

Location: SW11, Twp 14, Rge 14, W4
Classification: Orthic Brown Chernozemic
Parent material: Fluvial or lacustrine veneer over till

| Horizon | Depth cm | |
|---|---|---|
| Ah1 | 0-3 | Brown (10YR 5/3 d); loam; very weak, very fine granular; loose; abundant, fine, random roots; clear, wavy boundary; 2-4 cm thick; neutral. |
| Ah2 | 3-10 | Brown (10YR 4.5/3 d); loam; moderate, medium, subangular blocky; slightly hard; abundant, fine, vertical roots; gradual, wavy boundary; 5-8 cm thick; neutral. |
| Bm | 10-21 | Dark brown (10YR 4/3 d); loam; weak to moderate, fine to medium, subangular blocky; slightly hard; plentiful, very fine, vertical roots; clear, wavy boundary; 12-15 cm thick; neutral. |
| BCk | 21-32 | Yellowish brown (10YR 5/4 d); silt loam; weak to moderate, medium, subangular blocky; slightly hard; plentiful, very fine, vertical roots; moderate effervescence; clear, wavy boundary; 7-12 cm thick; mildly alkaline. |
| IICca | 32-50 | Pale brown (10YR 6/3 d); loam till; weak to moderate, fine to medium, subangular blocky; slightly hard; very few, very fine, vertical roots; moderate effervescence; contains 20% by volume of gravelly and angular gravelly fragments; gradual, irregular boundary; 14-18 cm thick; moderately alkaline. |
| IICk | 50+ | Brown to pale brown (10YR 5.5/3 d); clay loam; weak to |

moderate, fine to medium, subangular blocky; slightly hard; very few, very fine, vertical roots; moderate effervescence; contains 20% by volume of gravelly and angular gravelly fragments; moderately alkaline.

| Hor. | Depth cm | pH ($H_2O$) | % N | % O.C. | Exchangeable cations meq/100 g Na | K | Ca | Mg | T.E.C. meq/100 g | Ca/Na ratio | % $CaCO_3$ equiv. | Particle size % sand | % silt | % clay | Text. | E.C. mS/cm | S.A.R. | Est. avail. moist. cm/cm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ah1 | 0-3 | 7.2 | 0.2 | 1.7 | 0.1 | 1.0 | 10.4 | 2.7 | 14.2 | - | 0.2 | 40 | 46 | 14 | L | - | - | 0.09 |
| Ah2 | 3-10 | 7.3 | 0.2 | 1.1 | tr | 0.9 | 11.5 | 3.0 | 15.4 | - | 0.2 | 41 | 42 | 17 | L | - | - | 0.06 |
| Bm | 10-21 | 7.2 | 0.1 | 0.8 | tr | 0.8 | 11.7 | 3.5 | 15.4 | - | 0.2 | 40 | 42 | 18 | L | - | - | 0.06 |
| BCk | 21-32 | 7.7 | - | - | - | - | - | - | - | - | 5.1 | 33 | 51 | 16 | SiL | - | - | 0.12 |
| IICca | 32-50 | 8.0 | - | - | - | - | - | - | - | - | 14.1 | 36 | 45 | 19 | L | - | - | 0.11 |
| IICk | 50+ | 8.3 | - | - | - | - | - | - | - | - | 11.1 | 33 | 44 | 23 | L | - | - | 0.12 |

CHIN SERIES

Location: SW33, Twp 16, Rge 13, W4
Classification: Orthic Brown Chernozemic
Parent material: Fluvial or lacustrine

| Horizon | Depth cm | |
|---|---|---|
| Ah | 0-13 | Very dark grayish brown (10YR 3/2 m), brown to dark brown (10YR 4/3 d); silt loam; weak, fine granular; very friable; abundant, very fine and fine, random roots; gradual, smooth boundary; 10-15 cm thick; mildly alkaline. |
| Bm | 13-33 | Dark yellowish brown (10YR 4/4 m), yellowish brown (10YR 5/4 d); silt loam; compound, weak, medium prismatic, and weak, medium subangular blocky; friable; plentiful, very fine, vertical roots; clear, smooth boundary; 15-23 cm thick; mildly alkaline. |
| Cca1 | 33-53 | Yellowish brown (10YR 5/4 m,d); silt loam; very weak massive; very friable; plentiful, very fine, vertical roots; moderate effervescence; gradual, wavy boundary; 15-23 cm thick; mildly alkaline. |
| Cca2 | 53-86 | Yellowish brown (10YR 5/4 m,d); silt loam; very weak massive; very friable; few, very fine, vertical roots; moderate effervescence; diffuse, wavy boundary; 25-38 cm thick; mildly alkaline. |
| Ck1 | 86-109 | Olive brown (2.5Y 4/4 m); silt loam; very weak massive; very friable; few, vertical roots; weak effervescence; diffuse, wavy boundary; 20-36 cm thick; mildly alkaline. |
| Ck2 | 109-140 | Olive brown (2.5Y 4/4 m); silt loam; laminated massive; very friable; few, very fine, vertical roots; weak effervescence; clear, wavy boundary; 25-38 cm thick; mildly alkaline. |

Csak 140-170+ Olive brown (2.5Y 4/4 m); silt loam; laminated massive; friable; very few, very fine, vertical roots; weak effervescence; mildly alkaline.

| Hor. | Depth cm | pH ($H_2O$) | % N | % O.C. | Exchangeable cations meq/100 g Na | K | Ca | Mg | T.E.C. meq/100 g | Ca/Na ratio | % $CaCO_3$ equiv. | Particle size % sand | % silt | % clay | Text. | E.C. mS/cm | S.A.R. | Est. avail. moist. cm/cm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ah | 0-13 | 7.5 | 0.2 | 2.6 | 0.1 | 2.5 | 19.6 | 4.6 | 30.6 | 196 | 0.6 | 14 | 62 | 24 | SiL | - | - | 0.15 |
| Bm | 13-33 | 7.4 | 0.1 | 1.1 | 1.5 | 0.8 | 18.9 | 7.7 | 28.5 | 12 | 0.6 | 7 | 75 | 18 | SiL | - | - | 0.10 |
| Cca1 | 33-53 | 7.7 | - | - | - | - | - | - | - | - | 16.2 | 5 | 75 | 20 | SiL | - | - | 0.17 |
| Cca2 | 53-86 | 7.8 | - | - | - | - | - | - | - | - | 13.6 | 2 | 76 | 22 | SiL | - | - | 0.17 |
| | | | | | Soluble salts meq/L | | | | | | | | | | | | | |
| Ck1 | 86-109 | 7.7 | - | - | 4.2 | 0.6 | 18.8 | 12.1 | - | - | 7.4 | 2 | 75 | 23 | SiL | 3 | 1 | 0.18 |
| Ck2 | 109-140 | 7.8 | - | - | - | - | - | - | - | - | 6.8 | 1 | 77 | 22 | SiL | - | - | 0.22 |
| Csak | 140-170 | 7.8 | - | - | 17.4 | 1.0 | 25.0 | 21.6 | - | - | 5.0 | 1 | 77 | 22 | SiL | 4 | 4 | 0.23 |

DUCHESS SERIES

Location: SW19, Twp 17, Rge 13, W4
Classification: Brown Solodized Solonetz
Parent material: Fluvial or lacustrine veneer over till

Horizon Depth cm

Ah1 0-3 Dark grayish brown (10YR 4/2 m), pale brown (10YR 6/3 d); silt loam; very weak, medium granular; very friable; slightly plastic; abundant, very fine, random roots; abrupt, smooth boundary; 2-3 cm thick; slightly acid.

Ah2 3-9 Dark brown (10YR 3/3 m), brown (10YR 5/3 d); loam; weak, medium to fine granular; friable; slightly plastic; plentiful, fine, vertical roots; clear, smooth boundary; 5-7 cm thick; neutral.

Ahe 9-13 Dark brown to brown (10YR 4.5/3 m), brown (10YR 5/3 d); silt loam; weak, medium, granular; friable; slightly plastic; plentiful, fine, vertical roots; abrupt, smooth boundary; 3-5 cm thick; neutral.

Ae 13-18 Pale brown (10YR 6/3 d); silt loam, weak, fine granular; slightly hard; nonplastic; plentiful, fine, vertical roots; abrupt, wavy boundary; 4-6 cm thick; neutral.

Bnt 18-28 Dark brown (10YR 3.5/3 m), dark yellowish brown (10YR 4/4 crushed); clay loam; compound, strong, very coarse columnar, and moderate, medium to coarse, subangular blocky; very firm; plastic; plentiful, fine, vertical, exped roots; gradual, wavy boundary; 8-10 cm thick; moderately alkaline.

BCks 28-43 Dark brown (10YR 3.5/3 m), dark yellowish brown (10YR 4/4 crushed); clay loam; moderate, medium to coarse, subangular

blocky; firm; plastic; plentiful, fine, vertical roots; weak effervescence; clear, wavy boundary; 15-17 cm thick; moderately alkaline.

IICcasa 43-51 Dark brown (10YR 3.5/3 m), dark yellowish brown (10YR 3/4 crushed); gritty, clay loam till; weak to moderate, coarse, subangular blocky; firm; slightly plastic; few, fine, vertical roots; moderate effervescence; contains gravelly coarse fragments; gradual, wavy boundary; 6-8 cm thick; moderately alkaline.

IICksa 51-80+ Brown (10YR 5/3 m); sandy clay loam; moderate, medium to coarse, subangular blocky; firm; slightly plastic; very few, very fine, vertical roots; moderate effervescence; contains gravelly coarse fragments; moderately alkaline.

| Hor. | Depth cm | pH ($H_2O$) | % N | % O.C. | Exchangeable cations meq/100 g Na | K | Ca | Mg | T.E.C. meq/100 g | Ca/Na ratio | % $CaCO_3$ equiv. | Particle size % sand | % silt | % clay | Text. | E.C. mS/cm | S.A.R. | Est. avail. moist. cm/cm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ah1 | 0-3 | 6.3 | 5.8 | 3.2 | 0.1 | 1.5 | 8.1 | 2.9 | 24.2 | 81 | - | 28 | 56 | 16 | SiL | - | - | 0.17 |
| Ah2 | 3-9 | 6.7 | 0.2 | 1.7 | 0.4 | 1.4 | 6.1 | 2.5 | 17.4 | 15 | - | 34 | 52 | 14 | SiL | - | - | 0.13 |
| Ahe | 9-13 | 7.3 | 0.1 | 0.3 | 2.4 | 0.9 | 3.5 | 2.1 | 12.7 | 2 | - | 37 | 51 | 12 | SiL | - | - | 0.10 |
| Ae | 13-18 | 7.3 | 0.1 | 0.5 | 2.2 | 0.9 | 4.6 | 2.1 | 10.2 | 2 | - | 37 | 52 | 11 | SiL | - | - | 0.12 |
| | | | | | Soluble salts meq/L | | | | | | | | | | | | | |
| Bnt | 18-28 | 7.9 | 0.1 | 0.7 | 5.0 | 0.5 | 0.8 | 0.5 | - | - | - | 28 | 49 | 23 | L | 1 | 4 | 0.14 |
| BCks | 28-43 | 8.1 | - | - | 31.3 | 0.5 | 2.2 | 2.2 | - | - | 0.4 | 27 | 32 | 41 | C | 3 | 21 | 0.18 |
| IICcasa | 43-51 | 8.0 | - | - | 63.5 | 1.2 | 20.5 | 15.0 | - | - | 7.6 | 40 | 24 | 26 | L | 8 | 15 | 0.11 |
| IICksa | 51-80+ | 8.1 | - | - | 58.3 | 0.9 | 9.8 | 9.5 | - | - | 3.7 | 53 | 30 | 17 | VFSL | 7 | 19 | 0.09 |

DISHPAN SERIES

Location: SW4, Twp 30, Rge 10, W4
Classification: Rego Gleysol, saline phase
Parent material: Fluvial or lacustrine

Horizon Depth cm

ACs 0-5 Dark grayish brown (2.5Y 4/2 m); silt loam; compound, weak, irregular columnar, and weak, medium, subangular blocky; firm; abundant, fine and very fine, random roots; weakly saline; abrupt, smooth boundary; 2-8 cm thick; moderately alkaline.

Cgsk1 5-38 Olive (5Y 4/3 m); silt loam; massive; very sticky; plentiful, fine and very fine, vertical roots; weakly effervescent; strongly saline; gradual, smooth boundary; 20-36 cm thick; moderately alkaline.

Cgsk2 38-61 Olive (5Y 4/3 m); silt loam to silty clay loam; massive; very sticky; few, fine and very fine, vertical roots; weakly effervescent; strongly saline; gradual, wavy boundary; 20-30 cm thick; moderately alkaline.

Cgsk3 61-91 Olive (5Y 4/3 m); clay; massive; very sticky; very few, very fine, vertical roots; very weakly effervescent; strongly saline; diffuse boundary; 25-46 cm thick; moderately alkaline.

Cgsk4 91-107 Olive (5Y 4/3 m); silty clay loam; massive; very sticky; very weakly effervescent; moderately saline; strongly alkaline.

| Hor. | Depth cm | pH ($H_2O$) | % N | % O.C. | Exchangeable cations meq/100 g Na | K | Ca | Mg | T.E.C. meq/100 g | Ca/Na ratio | % $CaCO_3$ equiv. | Particle size % sand | % silt | % clay | Text. | E.C. mS/cm | S.A.R. | Est. avail. moist. cm/cm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ACs | 0-5 | 8.4 | 0.2 | 1.9 | - | - | - | - | - | - | 0.8 | 27 | 61 | 12 | SiL | 4 | - | - |
| Cgsk1 | 5-38 | 8.4 | - | - | - | - | - | - | - | - | 0.3 | 19 | 63 | 18 | SiL | 33 | - | - |
| Cgsk2 | 38-61 | 8.2 | - | - | - | - | - | - | - | - | 0.2 | 15 | 60 | 25 | SiL | 27 | - | - |
| Cgsk3 | 61-91 | 8.3 | - | - | - | - | - | - | - | - | 1.1 | 9 | 39 | 52 | C | 19 | - | - |
| Cgsk4 | 91-107 | 8.5 | - | - | - | - | - | - | - | - | 3.7 | 14 | 46 | 40 | SiCL | 11 | - | - |

FOREMOST SERIES

Location: NW28, Twp 19, Rge 7, W4
Classification: Orthic Brown Chernozemic
Parent material: Till

Horizon Depth cm

Ah 0-8 Brown to dark brown (10YR 4/3 m), brown to dark brown (10YR 5/3-4/3 d); loam; compound, moderate, coarse prismatic, and weak, fine granular; slightly hard; abundant, fine and very fine, random roots; clear, smooth boundary; 5-12 cm thick; neutral.

Bm 8-23 Dark yellowish brown (10YR 4/4 m), brown to yellowish brown (10YR 5/3-5/4 d); loam to silt loam; compound, strong, medium to coarse prismatic, and moderate, medium, subangular blocky; hard; abundant, fine and very fine, vertical roots; abrupt, wavy boundary; 12-20 cm thick; mildly alkaline.

Cca 23-76 Very pale brown (10YR 7/3 m), light gray (10YR 7/2 d); loam; compound, weak, coarse prismatic, and massive; slightly hard; few, very fine, vertical roots; contains 5% stones; strong effervescence; diffuse, wavy boundary; 45-55 cm thick; moderately alkaline.

Csk 76-107+ Pale brown (10YR 6/3 m, d); loam; massive; slightly hard; very few, micro, vertical roots; contains 5% stones; moderate to strong effervescence; mildly alkaline.

| Hor. | Depth cm | pH ($H_2O$) | % N | % O.C. | Exchangeable cations meq/100 g Na | K | Ca | Mg | T.E.C. meq/100 g | Ca/Na ratio | % $CaCO_3$ equiv. | Particle size % sand | % silt | % clay | Text. | E.C. mS/cm | S.A.R. | Est. avail. moist. cm/cm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ah | 0-8 | 7.1 | 0.2 | 2.2 | tr | 1.0 | 8.9 | 2.4 | 16.5 | 297 | - | 36 | 44 | 20 | L | - | - | 0.12 |
| Bm | 8-23 | 7.4 | 0.1 | 1.0 | 0.1 | 0.6 | 15.8 | 4.9 | 23.2 | 158 | - | 27 | 46 | 27 | L | <1 | <1 | 0.09 |
| | | | | | Soluble salts meq/L | | | | | | | | | | | | | |
| Cca | 23-76 | 8.1 | - | - | 1.4 | 0.2 | 1.5 | 0.6 | - | - | 9.6 | 41 | 37 | 22 | L | <1 | 1 | - |
| Csk | 76-107+ | 7.8 | - | - | 8.7 | 1.5 | 23.4 | 11.1 | - | - | 7.5 | 43 | 35 | 22 | L | 7 | 2 | - |

## HALLIDAY SERIES

Location: NW23, Twp 18, Rge 15, W4
Classification: Brown Solod
Parent material: Till

| Horizon | Depth cm | |
|---|---|---|
| Ah | 0-10 | Dark grayish brown (10YR 4/2 m), grayish brown (10YR 5/2 d); silt loam; weak, fine granular; very friable; abundant, fine and very fine, random roots; clear, wavy boundary; 7-12 cm thick; medium acid. |
| AB | 10-28 | Grayish brown (10YR 5/2 m), yellowish brown (10YR 5/4 d); loam; compound, weak, coarse prismatic, and moderate, fine and medium platy; very friable; plentiful, very fine, vertical roots; clear, wavy boundary; 5-20 cm thick; slightly acid. |
| Bnt | 28-46 | Brown to dark brown (10YR 4/3 m, ped 3/3), yellowish brown (10YR 5/4 d crushed); loam; compound, moderate to strong, coarse columnar, and strong, medium and coarse, subangular blocky; firm; plentiful, fine, vertical, exped roots; many, moderately thick clay skins on ped faces; gradual, wavy boundary; 12-22 cm thick; mildly alkaline. |
| BCs | 46-71 | Yellowish brown (10YR 5/4 d); loam; compound, weak, coarse columnar, and moderate, medium, subangular blocky; firm; very few, very fine, vertical roots; clear, wavy boundary; 18-30 cm thick; mildly alkaline. |
| Ccas | 71-94 | Brown to dark brown (10YR 4/3 m), gray (10YR 5/1 d); loam to clay loam; massive; friable; moderate effervescence; gradual, wavy boundary; 20-30 cm thick; moderately alkaline. |
| Csk1 | 94-127 | Dark grayish brown (10YR 4/2 m), grayish brown (10YR 5/2 d); loam to clay loam; massive; firm; weak effervescence; gradual, wavy boundary; 25-35 cm thick; moderately alkaline. |
| Csk2 | 127-190 | Brown to dark brown (10YR 4/3 m), dark gray to gray (10YR 4/1-5/1 d); loam to clay loam; massive; firm; weak effervescence; mildly alkaline. |

| Hor. | Depth cm | pH ($H_2O$) | % N | % O.C. | Exchangeable cations meq/100 g Na | K | Ca | Mg | T.E.C. meq/100 g | Ca/Na ratio | % $CaCO_3$ equiv. | Particle size % sand | % silt | % clay | Text. | E.C. mS/cm | S.A.R. | Est. avail. moist. cm/cm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ah | 0-10 | 5.9 | 0.2 | 1.8 | 0.2 | 1.2 | 3.8 | 1.2 | 12.4 | 21 | - | 36 | 52 | 12 | SiL | - | - | - |
| AB | 10-28 | 6.2 | 0.1 | 0.8 | 0.5 | 0.5 | 1.4 | 1.4 | 8.3 | 3 | - | 43 | 46 | 11 | L | - | - | - |
| Bnt | 28-46 | 7.6 | 0.2 | 0.7 | 3.2 | 0.9 | 4.5 | 6.7 | 16.9 | 1 | - | 32 | 45 | 23 | L | 1 | 5 | - |
| | | | | | Soluble salts meq/L | | | | | | | | | | | | | |
| BCs | 46-71 | 7.8 | - | - | 12.6 | 1.0 | 23.4 | 6.0 | - | - | - | 44 | 37 | 19 | L | 8 | 3 | - |
| Ccas | 71-94 | 7.9 | - | - | 20.4 | 1.4 | 22.3 | 8.4 | - | - | 7.4 | 38 | 36 | 26 | L | 10 | 5 | - |
| Csk1 | 94-127 | 8.0 | - | - | 33.9 | 1.3 | 23.7 | 9.9 | - | - | 2.3 | 38 | 35 | 27 | L | 11 | 8 | - |
| Csk2 | 127-190 | 7.7 | - | - | 40.0 | 1.3 | 23.3 | 8.2 | - | - | 2.0 | 40 | 37 | 23 | L | 13 | 10 | - |

## HEMARUKA SERIES

Location: SE6, Twp 20, Rge 15, W4
Classification: Brown Solodized Solonetz
Parent material: Till

| Horizon | Depth cm | |
|---|---|---|
| Ah | 0-3 | Brown to dark brown (10YR 4/3 d); loam; weak, fine, granular; loose; abundant, fine, random roots; abrupt, smooth boundary; 2-4 cm thick; neutral. |
| Ae | 3-7 | Grayish brown (10YR 5/2 d); loam; moderate, fine platy; soft; abundant, fine and medium, vertical roots; abrupt, smooth boundary; 2-5.5 cm thick; neutral. |
| Bnt1 | 7-17 | Dark grayish brown (2.5Y 4/2 m); clay loam; strong, medium, columnar; extremely hard; plentiful, fine and medium, vertical, exped roots, often compressed; abrupt, smooth boundary; 8-12 cm thick; neutral. |
| Bnt2 | 17-25 | Brown to dark brown (10YR 4/3 d); clay; strong, medium to coarse, angular blocky; very hard; plentiful, fine and medium, vertical roots; clear, smooth boundary; 6-10 cm thick; mildly alkaline. |
| Cca | 25-40 | Light olive brown (2.5Y 5/4 d); clay loam; moderate, medium, subangular blocky; very hard; plentiful, fine and medium, vertical roots; moderate effervescence; clear, smooth boundary; 12-18 cm thick; moderately alkaline. |
| Ck1 | 40-60 | Dark grayish brown (2.5Y 4/2 d); loam; moderate, coarse, angular blocky; very hard; plentiful, fine and medium, vertical roots; weak effervescence; clear, smooth boundary; 16-24 cm thick; moderately alkaline. |
| Ck2 | 60-78 | Dark grayish brown (2.5Y 4/2 d); clay loam; weak, medium to coarse, angular blocky; very hard; few, fine, vertical roots; weak effervescence; abrupt, smooth boundary; 16-20 cm thick; moderately alkaline. |

Ck3 78-94 Yellowish brown (10YR 5/4 d); sandy loam; single grain; loose; weak effervescence; abrupt, smooth boundary; 14-17 cm thick; strongly alkaline.

Ck4 94 Dark grayish brown (2.5Y 4/2 d); loam; massive; very hard; weak effervescence; moderately alkaline.

| Hor. | Depth cm | pH ($H_2O$) | % N | % O.C. | Exchangeable cations meq/100 g Na | K | Ca | Mg | T.E.C. meq/100 g | Ca/Na ratio | % $CaCO_3$ equiv. | Particle size % sand | % silt | % clay | Text. | E.C. mS/cm | S.A.R. | Est. avail. moist. cm/cm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ah | 0-3 | 6.8 | 0.2 | 2.7 | 0.7 | 0.9 | 9.5 | 3.5 | 15.3 | 14 | - | 42 | 44 | 14 | L | - | - | - |
| Ae | 3-7 | 6.8 | 0.2 | 1.6 | 2.0 | 0.5 | 6.3 | 2.3 | 11.4 | 3 | - | 44 | 45 | 11 | L | - | - | - |
| Bnt1 | 7-17 | 7.2 | 0.1 | 1.3 | 4.2 | 1.0 | 14.2 | 4.8 | 23.7 | 3 | 0.4 | 32 | 36 | 32 | CL | - | - | - |
| Bnt2 | 17-25 | 7.9 | 0.1 | 1.3 | 8.5 | 1.3 | 25.5 | 9.0 | 31.7 | 3 | 1.1 | 29 | 29 | 42 | C | - | - | - |
| Cca | 25-40 | 8.1 | - | - | - | - | - | - | - | - | 7.9 | 32 | 35 | 33 | CL | - | - | - |
| Ck1 | 40-60 | 8.3 | - | - | - | - | - | - | - | - | 3.5 | 39 | 35 | 26 | L | - | - | - |
| Ck2 | 60-78 | 8.4 | - | - | - | - | - | - | - | - | 4.5 | 34 | 36 | 30 | CL | - | - | - |
| Ck3 | 78-94 | 8.6 | - | - | - | - | - | - | - | - | 2.9 | 61 | 22 | 17 | SL | - | - | - |
| Ck4 | 94+ | 8.0 | - | - | - | - | - | - | - | - | 2.0 | 44 | 22 | 34 | CL | - | - | - |

KARLSBAD SERIES

Location: NE36, Twp 17, Rge 14, W4
Classification: Brown Solod
Parent material: Fluvial or lacustrine

Horizon Depth cm

Ah 0-5 Brown to dark brown (10YR 4/3 m), grayish brown (10YR 5/2 d); silt loam; weak, medium granular; very friable; abundant, very fine, random roots; clear, smooth boundary; 4-8 cm thick; slightly acid.

Ae 5-12 Brown (10YR 5/3 m), light brownish gray (10YR 6/2 d); silt loam; moderate, fine platy; very friable; abundant, very fine, vertical roots; clear, wavy boundary; 5-8 cm thick; slightly acid.

AB 12-15 Dark brown (10YR 3/3 m), dark brown to brown (10YR 4/3 d); loam to silt loam; moderate, fine, subangular blocky; friable; abundant, very fine, vertical roots; clear, smooth boundary; 2-5 cm thick; slightly acid.

Btnj 15-33 Dark brown (10YR 3/3 m, ped face and crushed); clay loam; compound, moderate, fine columnar, and moderate, medium, subangular blocky; firm; plentiful, very fine, vertical, exped roots; common, thin clay skins on ped faces; gradual, wavy boundary; 15-22 cm thick; mildly alkaline.

BCk 33-40 Dark brown to brown (10YR 4/3 m); silty clay loam to clay loam; compound, weak, medium prismatic and moderate, medium, subangular blocky; friable; few, very fine, vertical roots; moderate effervescence; gradual, wavy boundary; 5-12 cm thick; moderately alkaline.

Cca 40-106 Yellowish brown (10YR 5/4 m); silt loam; weak, medium, irregular blocky; friable; strong effervescence; gradual, wavy boundary; 55-68 cm thick; moderately alkaline.

Csk 106-238 Very pale brown (10YR 7/3 m); silty clay loam; massive; firm; very weak effervescence; gradual, wavy boundary; 100-140 cm thick; mildly alkaline.

IICsk 238+ Dark brown to brown (10YR 4/3 m); silty clay loam; massive; very firm; many, medium, distinct, brownish yellow (10YR 6/6) mottles; very weak effervescence; mildly alkaline.

| Hor. | Depth cm | pH ($H_2O$) | % N | % O.C. | Exchangeable cations meq/100 g Na | K | Ca | Mg | T.E.C. meq/100 g | Ca/Na ratio | % $CaCO_3$ equiv. | Particle size % sand | % silt | % clay | Text. | E.C. mS/cm | S.A.R. | Est. avail. moist. cm/cm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ah | 0-5 | 6.5 | 0.3 | 3.9 | 0.1 | 1.7 | 9.5 | 3.0 | 19.7 | 136 | - | 24 | 55 | 21 | SiL | - | - | 0.18 |
| Ae | 5-12 | 6.1 | 0.2 | 1.5 | 0.1 | 1.4 | 7.3 | 2.2 | 15.7 | 67 | - | 26 | 55 | 19 | SiL | - | - | 0.15 |
| AB | 12-15 | 6.3 | 0.1 | 0.9 | 0.4 | 0.6 | 7.8 | 5.4 | 17.9 | 18 | - | 27 | 49 | 24 | SiL | - | - | 0.10 |
| Btnj | 15-33 | 7.5 | 0.1 | 1.0 | 1.0 | 0.8 | 13.3 | 8.7 | 29.2 | 13 | - | 23 | 41 | 36 | CL | <1 | 2 | 0.13 |
| | | | | | Soluble salts meq/L | | | | | | | | | | | | | |
| BCk | 33-40 | 8.1 | 0.1 | 0.7 | 2.3 | 0.1 | 1.8 | 0.4 | - | - | 3.3 | 19 | 48 | 33 | SiCL | <1 | 2 | - |
| Cca | 40-106 | 8.1 | - | - | 1.0 | 0.1 | 1.8 | 0.3 | - | - | 12.0 | 7 | 69 | 24 | SiL | <1 | 1 | - |
| Csk | 106-238 | 7.5 | - | - | 28.9 | 0.4 | 32.9 | 7.2 | - | - | 1.8 | 1 | 68 | 31 | SiCL | 12 | 6 | - |
| IICsk | 238+ | 7.8 | - | - | 33.0 | 0.1 | 13.3 | 2.2 | - | - | 0.8 | 17 | 50 | 33 | SiCL | 9 | 12 | - |

PATRICIA SERIES

Location: NE9, Twp 21, Rge 16, W4
Classification: Brown Solodized Solonetz
Parent material: Lacustrine

Horizon Depth cm

Ah 0-8 Dark grayish brown (10YR 4/2 m); loam to silt loam; weak, fine granular; friable; abundant, very fine, random roots; clear, smooth boundary; 5-10 cm thick; mildly alkaline.

Ae 8-15 Dark grayish brown (10YR 4/2 m); loam to silt loam; moderate, medium platy; friable; plentiful, very fine, random roots; abrupt, wavy boundary; 5-9 cm thick; neutral.

Bnt 15-30 Olive brown (2.5Y 4/4 m); clay; compound, moderate to strong, fine columnar, and moderate, fine, subangular blocky; firm; plentiful, very fine, vertical, exped roots; clear, smooth boundary; 10-18 cm thick; neutral.

Ck 30-51 Olive brown (2.5Y 4/4 d); clay loam to silty clay loam; moderate, fine, angular blocky; hard; plentiful, very fine, vertical roots; moderate effervescence; gradual, wavy boundary; 18-28 cm thick; moderately alkaline.

Csk 51-66+ Olive brown (2.5Y 4/4 d); clay to silty clay; weak, fine, angular blocky to massive; hard; few, very fine, vertical roots; weak effervescence; mildly alkaline.

| Hor. | Depth cm | pH ($H_2O$) | % N | % O.C. | Exchangeable cations meq/100 g Na | K | Ca | Mg | T.E.C. meq/100 g | Ca/Na ratio | % $CaCO_3$ equiv. | Particle size % sand | % silt | % clay | Text. | E.C. mS/cm | S.A.R. | Est. avail. moist. cm/cm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ah | 0-8 | 7.4 | 0.2 | 3.1 | 1.3 | 0.9 | 14.2 | 5.3 | 21.0 | 11 | - | 32 | 49 | 19 | L | - | - | - |
| Ae | 8-15 | 7.2 | 0.1 | 1.2 | 2.0 | 0.4 | 7.9 | 4.5 | 12.8 | 4 | - | 37 | 49 | 14 | L | - | - | - |
| Bnt | 15-30 | 7.2 | 0.1 | 1.2 | 6.5 | 1.4 | 17.4 | 14.2 | 34.8 | 3 | 0.1 | 21 | 26 | 51 | C | <1 | - | - |
| Ck | 30-51 | 8.1 | - | - | - | - | - | - | - | - | 9.0 | 21 | 41 | 38 | CL | <1 | - | - |
| | | | | | Soluble salts meq/L | | | | | | | | | | | | | |
| Csk | 51-66+ | 7.8 | - | - | 13.2 | - | 1.8 | 1.7 | - | - | 8.6 | 16 | 39 | 45 | C | 2 | 9 | - |

## ROLLING HILLS SERIES

**Location:** NE9, Twp 16, Rge 13, W4
**Classification:** Brown Solodized Solonetz
**Parent material:** Sandy fluvial or eolian veneer over till

| Horizon | Depth cm | |
|---|---|---|
| Ah1 | 0-2 | Brown (10YR 5/3 d); sandy loam; very weak, very fine granular; loose; abundant, very fine, random roots; abrupt, smooth boundary; 2-3 cm thick; slightly acid. |
| Ah2 | 2-15 | Brown (10YR 4.5/3 d); sandy loam; very weak, very fine to fine, single grain to granular; loose; plentiful, very fine, vertical roots; gradual, wavy boundary; 12-16 cm thick; medium acid. |
| Ahe | 15-32 | Yellowish brown (10YR 5/4 d); loamy sand; single grain; plentiful, very fine, vertical roots; abrupt, smooth boundary; 14-15 cm thick; slightly acid. |
| IIBnt | 32-47 | Dark brown (10YR 3.5/3 exped m), yellowish brown (10YR 5/4 d); clay loam till; compound, strong, coarse columnar, and moderate to strong, medium, subangular blocky; extremely hard; few, very fine, vertical, exped roots; abrupt, wavy boundary; 13-17 cm thick; moderately alkaline. |
| IICca | 47-63 | Yellowish brown to light yellowish brown (10YR 5.5/4 d); silty clay; weak to moderate, coarse, subangular blocky; soft; very few, very fine, vertical roots; strong effervescence; gradual, wavy boundary; 13-18 cm thick; moderately alkaline. |
| IICk | 63+ | Brown to light yellowish brown (10YR 5.5/3.5 d); silty clay loam; weak, medium, angular blocky to massive; soft; very few, very fine, vertical roots; moderate effervescence; moderately alkaline. |

| Hor. | Depth cm | pH ($H_2O$) | % N | % O.C. | Exchangeable cations meq/100 g Na | K | Ca | Mg | T.E.C. meq/100 g | Ca/Na ratio | % $CaCO_3$ equiv. | Particle size % sand | % silt | % clay | Text. | E.C. mS/cm | S.A.R. | Est. avail. moist. cm/cm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ah1 | 0-2 | 6.3 | 0.2 | 2.6 | tr | 1.0 | 7.1 | 2.6 | 19.4 | - | - | 69 | 19 | 12 | FSL | - | - | 0.04 |
| Ah2 | 2-15 | 5.6 | 0.1 | 0.8 | 0.1 | 0.5 | 2.8 | 1.4 | 10.9 | 28 | - | 73 | 18 | 9 | FSL | - | - | 0.04 |
| Ahe | 15-32 | 6.4 | tr | 0.3 | 0.3 | 0.2 | 2.3 | 1.9 | 7.6 | 7 | - | 84 | 11 | 5 | LFS | - | - | 0.01 |
| | | | | | Soluble salts meq/L | | | | | | | | | | | | | |
| IIBnt | 32-47 | 8.0 | 0.1 | - | 12.2 | 0.3 | 1.2 | 1.8 | - | - | 3.8 | 39 | 31 | 30 | CL | 1 | 10 | 0.11 |
| IICca | 47-63 | 7.9 | - | - | - | - | - | - | - | - | 21.5 | 6 | 46 | 48 | SIC | - | - | 0.15 |
| IICk | 63+ | 8.0 | - | - | - | - | - | - | - | - | 9.2 | 3 | 59 | 38 | SICL | - | - | 0.20 |

RAINIER SERIES

Location: NW35, Twp 15, Rge 13, W4
Classification: Orthic Brown Chernozemic
Parent material: Coarse loamy fluvial veneer over lacustrine

| Horizon | Depth cm | |
|---|---|---|
| Ah1 | 0-3 | Dark grayish brown (10YR 4/2 d); loam; very weak, very fine granular; loose; nonplastic; abundant, fine, random roots; abrupt, smooth boundary; 2-4 cm thick; neutral. |
| Ah2 | 3-14 | Brown (10YR 5/3 d); sandy loam; very weak, very fine to fine granular; loose; nonplastic; plentiful, fine, vertical roots; gradual, wavy boundary; 10-14 cm thick; neutral. |
| Bm | 14-45 | Yellowish brown (10YR 5/4 d); loamy sand; very weak, very fine to fine granular; loose; nonplastic; plentiful, very fine, vertical roots; gradual, wavy boundary; 28-32 cm thick; neutral. |
| IIBm | 45-58 | Yellowish brown (10YR 5/4 d); loam; weak to moderate, medium, subangular blocky; soft; slightly plastic; few, very fine, vertical roots; clear, wavy boundary; 12-15 cm thick; neutral. |
| IIBC | 58-78 | Dark brown to brown (10YR 4/3 m); yellowish brown (10YR 5/4 d); silt loam; weak to moderate, medium subangular blocky; friable, slightly plastic; few, very fine, vertical roots; abrupt, smooth boundary; 18-23 cm thick; mildly alkaline. |
| IIICca | 78+ | Dark brown to brown (10YR 4/3 m), brown (10YR 4.5/3 d); loam till; weak to moderate, medium to coarse, subangular blocky; very friable; slightly plastic; very few, micro, vertical roots; moderate efferyescence; moderately alkaline. |

| | | | | | Exchangeable cations meq/100 g | | | | | | | Particle size | | | | | | Est. avail. moist. cm/cm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hor. | Depth cm | pH ($H_2O$) | % N | % O.C. | Na | K | Ca | Mg | T.E.C. meq/100 g | Ca/Na ratio | % $CaCO_3$ equiv. | % sand | % silt | % clay | Text. | E.C. mS/cm | S.A.R. | |
| Ah1 | 0-3 | 6.9 | 0.2 | 1.3 | 0.1 | 0.9 | 10.1 | 3.5 | 25.0 | 101 | - | 42 | 41 | 17 | L | - | - | 0.08 |
| Ah2 | 3-14 | 6.6 | 0.1 | 2.4 | 0.0 | 0.7 | 5.9 | 1.6 | 14.7 | - | - | 65 | 27 | 8 | FSL | - | - | 0.06 |
| Bm | 14-45 | 6.8 | tr | 0.4 | tr | 0.3 | 4.3 | 1.6 | 10.2 | - | - | 79 | 14 | 7 | LFS | - | - | 0.02 |
| IIBm | 45-58 | 7.2 | 0.1 | 0.5 | 0.5 | 0.8 | 12.9 | 4.6 | 25.0 | 26 | 0.3 | 31 | 49 | 20 | L | - | - | 0.09 |
| IIBc | 58-78 | 7.7 | - | - | - | - | - | - | - | - | 3.4 | 23 | 59 | 18 | SiL | - | - | 0.10 |
| IIICca | 78+ | 8.0 | - | - | - | - | - | - | - | - | 8.8 | 50 | 32 | 18 | L | - | - | 0.07 |

ROSEMARY SERIES

Location: NW19, Twp 22, Rge 16, W4
Classification: Brown Solod
Parent material: Lacustrine

| Horizon | Depth cm | |
|---|---|---|
| Ah | 0-3 | Dark grayish brown (10YR 4/2 m), grayish brown (10YR 6/2 d); silt loam; weak, fine granular; very friable; abundant, fine, random roots; clear, smooth boundary; 2-6 cm thick; mildly alkaline. |
| Ahe | 3-7 | Dark brown to brown (10YR 4/3 m), light brownish gray (10YR 6/2 d); silt loam; weak, fine granular; very friable; plentiful, fine, vertical roots; clear, smooth boundary; 3-5 cm thick; moderately alkaline. |
| Ae | 7-9 | Grayish brown (10YR 5/2 m), light gray (10YR 7/2 d); silt loam; compound, weak, fine platy, and single grain; very friable; plentiful, fine, vertical roots; clear, wavy boundary; 1-3 cm thick; moderately alkaline. |
| Bnt | 9-23 | Dark brown (10YR 3/3 ped), dark grayish brown (10YR 4/2 d); silty clay to clay; compound, moderate, medium columnar, and moderate, medium, subangular blocky; firm; plentiful, very fine, vertical, exped roots; clear, smooth boundary; 12-16 cm thick; moderately alkaline. |
| Cca | 23-46 | Dark yellowish brown (10YR 4/4 m); silty clay loam; moderate, fine, angular blocky; friable; plentiful, very fine, vertical roots; moderate effervescence; gradual, wavy boundary; 20-25 cm thick; moderately alkaline. |
| Csk | 46-71 | Dark yellowish brown (10 YR 4/4 m); silty clay loam; massive; few, very fine, vertical roots; weak effervescence; gradual, wavy boundary; 20-30 cm thick; mildly alkaline. |
| Ck | 71-97+ | Dark yellowish brown (10YR 4/4 m); silt loam to silty clay loam; weak effervescence; neutral. |

| | | | | | Exchangeable cations meq/100 g | | | | | | | Particle size | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hor. | Depth cm | pH ($H_2O$) | % N | % O.C. | Na | K | Ca | Mg | T.E.C. meq/100 g | Ca/Na ratio | % $CaCO_3$ equiv. | % sand | % silt | % clay | Text. | E.C. mS/cm | S.A.R. | Est. avail. moist. cm/cm |
| Ah | 0-3 | 7.8 | 0.3 | 2.6 | 0.9 | 2.5 | 24.8 | 13.6 | 25.5 | 28 | 1.8 | 20 | 59 | 21 | SiL | - | - | - |
| Ahe | 3-7 | 8.1 | 0.2 | 1.6 | 0.9 | 1.6 | 13.8 | 8.2 | 17.3 | 15 | 0.3 | 22 | 63 | 15 | SiL | - | - | - |
| Ae | 7-9 | 8.3 | 0.1 | 1.0 | 1.4 | 1.1 | 11.9 | 4.9 | 12.7 | 9 | 0.3 | 24 | 61 | 15 | SiL | - | - | - |
| Bnt | 9-23 | 8.1 | 0.1 | 1.2 | 6.1 | 1.7 | 14.4 | 32.1 | 37.0 | 2 | 0.5 | 10 | 40 | 50 | SiC | 1 | - | - |
| | | | | | Soluble salts meq/L | | | | | | | | | | | | | |
| Cca | 23-46 | 8.1 | - | - | 8.3 | - | 11.3 | 8.4 | - | - | 12.4 | 8 | 55 | 37 | SiCL | 3 | 3 | - |
| Csk | 46-71 | 7.8 | - | - | - | - | - | - | - | - | 10.0 | 2 | 60 | 38 | SiCL | 2 | - | - |
| Ck | 71-97+ | 7.3 | - | - | - | - | - | - | - | - | 7.2 | 11 | 62 | 27 | SiL | <1 | - | - |

## RONALAINE SERIES

Location: SW2, Twp 17, Rge 9, W4
Classification: Solonetzic Brown Chernozemic
Parent material: Till

| Horizon | Depth cm | |
|---|---|---|
| Ah | 0-7 | Dark brown to brown (10YR 4/3 m), grayish brown (10YR 5/2 d); clay loam to loam; weak, fine granular; loose to very friable; abundant, very fine, random roots; abrupt, smooth boundary; 5-8 cm thick; neutral. |
| Btnj | 7-15 | Very dark grayish brown (10YR 3/2 m), grayish brown (10YR 5/2 d); clay loam; compound, weak, medium, irregular prismatic, and weak, medium, subangular blocky; friable; abundant, very fine, vertical roots; many, thin clay films; clear, wavy boundary; 8-12 cm thick; mildly alkaline. |
| Ck | 15-51 | Dark brown to brown (10YR 4/3 m), light brownish gray (10YR 6/2 d); loam to clay loam; massive; firm; few, very fine, vertical roots; strong effervescence; gradual, wavy boundary; 30-40 cm thick; moderately alkaline. |
| Csk1 | 51-112 | Dark brown to brown (10YR 4/3 m), light brownish gray (10YR 6/2 d); loam; massive; firm; moderate effervescence; gradual, wavy boundary; 55-65 cm thick; mildly alkaline. |
| Csk2 | 112-157 | Grayish brown (10YR 5/2 m), pale brown (10YR 6/3 d); loam; massive; firm; weak effervescence; moderately alkaline. |

| Hor. | Depth cm | pH ($H_2O$) | % N | % O.C. | Exchangeable cations meq/100 g Na | K | Ca | Mg | T.E.C. meq/100 g | Ca/Na ratio | % $CaCO_3$ equiv. | Particle size % sand | % silt | % clay | Text. | E.C. mS/cm | S.A.R. | Est. avail. moist. cm/cm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ah | 0-7 | 7.0 | 0.2 | 1.5 | tr | 1.2 | 13.3 | 5.5 | 22.4 | 332 | - | 38 | 33 | 29 | CL | - | - | 0.10 |
| Btnj | 7-15 | 7.6 | 0.1 | 1.4 | 0.1 | - | - | - | 25.7 | - | 0.9 | 37 | 30 | 33 | CL | <1 | - | 0.07 |
| | | | | | Soluble salts meq/L | | | | | | | | | | | | | |
| Ck | 15-51 | 8.0 | - | - | 0.4 | 0.4 | 6.4 | 1.0 | - | - | 5.4 | 40 | 36 | 24 | L | 1 | <1 | - |
| Csk1 | 51-112 | 7.7 | - | - | 14.3 | 0.8 | 23.8 | 8.6 | - | - | 2.4 | 44 | 34 | 22 | L | 6 | 4 | - |
| Csk2 | 112-157 | 7.9 | - | - | 30.0 | 0.5 | 22.5 | 12.5 | - | - | 2.7 | 40 | 41 | 19 | L | 10 | 7 | - |

## STEVEVILLE SERIES

Location: NW19, Twp 19, Rge 12, W4
Classification: Brown Solodized Solonetz
Parent material: Modified Cretaceous soft rock

| Horizon | Depth cm | |
|---|---|---|
| Ah | 0-8 | Brown (10YR 5/3 m); sandy loam; weak, fine granular; very friable; abundant, very fine, random roots; clear, smooth boundary; 6-10 cm thick; neutral. |

| | | |
|---|---|---|
| Ae | 8-13 | Dark grayish brown (10YR 4/2 m), light brownish gray (10YR 6/2 d); sandy loam; compound, moderate, fine platy, and weak, fine granular; friable to very friable; plentiful, very fine, random roots; abrupt, wavy boundary; 3-6 cm thick; neutral. |
| Bnt | 13-36 | Dark brown (10YR 3/3 m), brown to dark brown (10YR 4/3 d), very dark grayish brown (10YR 3/2 ped); loam; compound, strong, coarse columnar, and strong, medium, subangular blocky; very firm; plentiful, very fine, vertical, exped roots; many, moderately thick, clay films; gradual, irregular boundary; 45-60 cm thick; mildly alkaline. |
| Ck | 36-58 | Very dark grayish brown (10YR 3/2 m,d); clay loam to loam; compound, weak, coarse, columnar, and strong, medium, subangular blocky; very firm; few, very fine, vertical, exped roots; weak effervescence; gradual, wavy boundary; 45-60 cm thick; moderately alkaline. |
| Csk | 58-91 | Very dark grayish brown (10YR 3/2 m,d); loam to clay loam; massive; very firm; moderate effervescence; gradual, wavy boundary; 75-90 cm thick; mildly alkaline. |
| IICs | 128-228 | Very dark gray (10YR 3/1 m); silty clay (shale); massive; very firm; weakly acid. |

| Hor. | Depth cm | pH ($H_2O$) | % N | % O.C. | Exchangeable cations meq/100 g Na | K | Ca | Mg | T.E.C. meq/100 g | Ca/Na ratio | % $CaCO_3$ equiv. | Particle size % sand | % silt | % clay | Text. | E.C. mS/cm | S.A.R. | Est. avail. moist. cm/cm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ah | 0-8 | 6.6 | 0.2 | 1.7 | 0.3 | 0.4 | 2.8 | 0.8 | 9.8 | 10 | - | 60 | 31 | 9 | SL | - | - | 0.11 |
| Ae | 8-13 | 6.6 | 0.1 | 1.1 | 0.6 | 0.2 | 2.5 | 0.9 | 8.5 | 4 | - | 57 | 33 | 10 | SL | - | - | 0.10 |
| Bnt | 13-36 | 7.4 | 0.1 | 1.2 | 2.9 | 0.5 | 7.8 | 6.0 | 18.4 | 3 | 0.2 | 43 | 33 | 24 | L | - | - | 0.09 |
| | | | | | Soluble salts meq/L | | | | | | | | | | | | | |
| Ck | 36-58 | 8.1 | - | - | 6.6 | 0.1 | 3.1 | 0.5 | - | - | 2.5 | 37 | 34 | 29 | CL | 2 | 3 | - |
| Csk | 58-91 | 7.7 | - | - | 17.0 | 0.4 | 15.4 | 2.9 | - | - | 1.4 | 38 | 36 | 26 | L | 6 | 6 | - |
| IICs | 128-228 | 7.5 | - | - | 304.3 | 4.3 | 18.1 | 45.3 | - | - | 0.1 | 3 | 50 | 47 | SIC | 14 | 54 | - |

TILLEY SERIES

Location: NE8, Twp 19, Rge 13, W4
Classification: Solonetzic Brown Chernozemic (formerly Eluviated Brown Chernozemic)
Parent material: Fluvial or lacustrine

| Horizon | Depth cm | |
|---|---|---|
| Ah1 | 0-5 | Brown to dark brown (10YR 4/3 m), grayish brown (10YR 5/2 d); silt loam; weak, medium granular; very friable; abundant, fine, random roots; clear, smooth boundary; 3-6 cm thick; neutral. |
| Ah2 | 5-15 | Brown (10YR 5/3 m); silt loam; moderate, medium, subangular blocky; friable; abundant, fine, vertical roots; clear, smooth boundary; 8-12 cm thick; neutral. |

| | | |
|---|---|---|
| Ae | 15-22 | Grayish brown (10YR 5/2 m); silt loam; weak, fine platy; friable; plentiful, fine, vertical roots; clear, wavy boundary; 4-7 cm thick; neutral. |
| Bt | 22-43 | Dark brown (10YR 3/3 m); silty clay loam; compound, moderate, medium prismatic, and moderate, fine, subangular blocky; friable; plentiful, fine, vertical roots; gradual, wavy boundary; 16-24 cm thick; mildly alkaline. |
| Csk1 | 43-60 | Yellowish brown (10YR 5/4 m); silt loam; massive; very friable; few, very fine, vertical roots; weak effervescence; gradual, wavy boundary; 18-25 cm thick; moderately alkaline. |
| Csk2 | 60-94+ | Pale brown (10YR 6/3 m); silt loam; massive; very friable; moderate effervescence; moderately alkaline. |

| Hor. | Depth cm | pH ($H_2O$) | % N | % O.C. | Exchangeable cations meq/100 g Na | K | Ca | Mg | T.E.C. meq/100 g | Ca/Na ratio | % $CaCO_3$ equiv. | Particle size % sand | % silt | % clay | Text. | E.C. mS/cm | S.A.R. | Est. avail. moist. cm/cm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ah1 | 0-5 | 6.8 | 0.3 | 4.4 | 1.2 | 1.2 | 16.7 | 14.7 | 24.0 | 14 | - | - | - | - | SiL | - | - | - |
| Ah2 | 5-15 | 6.9 | 0.2 | 1.9 | 2.4 | 0.8 | 8.9 | 4.5 | 19.0 | 4 | - | - | - | - | SiL | - | - | - |
| Ae | 15-22 | 7.2 | 0.1 | 1.0 | 2.9 | 1.1 | 16.0 | 4.7 | 14.0 | 6 | - | - | - | - | SiL | - | - | - |
| Bt | 22-43 | 7.7 | 0.1 | 1.2 | 1.1 | 2.7 | 16.7 | 3.8 | 34.2 | 15 | 0.2 | - | - | - | SiCL | - | - | - |
| | | | | | Soluble salts meq/L | | | | | | | | | | | | | |
| Csk1 | 43-60 | 8.2 | - | - | 59 | - | 8 | 14 | - | - | 4.1 | - | - | - | SiL | 5 | 18 | - |
| Csk2 | 60-94+ | 7.9 | - | - | 54 | - | 13 | 17 | - | - | 12.5 | - | - | - | SiL | 5 | 14 | - |

## VENDISANT SERIES

Location: NE36, Twp 22, Rge 16, W4
Classification: Rego Brown Chernozemic
Parent material: Sandy fluvial or eolian

| Horizon | Depth cm | |
|---|---|---|
| Ah | 0-47 | Dark brown (10YR 3/3 m), dark grayish brown (10YR 4/2 d); loamy sand; single grain; loose; plentiful, medium to micro, vertical roots; gradual, wavy boundary; 42-52 cm thick; neutral. |
| C1 | 47-86 | Brown to dark brown (10YR 4/3 m), brown (10YR 5/3 d); sand; single grain; loose; very few, medium and very fine, vertical roots; gradual, smooth boundary; 36-43 cm thick; neutral. |
| C2 | 86-112 | Yellowish brown (10YR 5/4 d); sand; single grain; loose to very friable; very few, medium, vertical roots; clear, wavy boundary; 22-30 cm thick; moderately alkaline. |
| Ck | 112-130+ | Brown (10YR 5/3 d); loamy sand; single grain; slightly hard; weak effervescence; moderately alkaline. |

| Hor. | Depth cm | pH ($H_2O$) | % N | % O.C. | Exchangeable cations meq/100 g Na | K | Ca | Mg | T.E.C. meq/100 g | Ca/Na ratio | % $CaCO_3$ equiv. | Particle size % sand | % silt | % clay | Text. | E.C. mS/cm | S.A.R. | Est. avail. moist. cm/cm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ah | 0-47 | 6.6 | 0.1 | 0.8 | tr | 0.5 | 5.2 | 1.2 | 6.7 | - | - | 86 | 10 | 4 | LFS | - | - | 0.03 |
| C1 | 47-86 | 7.0 | 0.1 | 0.4 | 0.1 | 0.5 | 5.1 | 1.1 | 6.1 | 51 | - | 88 | 9 | 3 | FS | - | - | 0.03 |
| C2 | 86-112 | 7.9 | tr | 0.4 | - | - | - | - | - | - | 0.6 | 86 | 10 | 4 | LFS | - | - | 0.03 |
| Ck | 112-130 | 8.1 | tr | 0.3 | - | - | - | - | - | - | 3.8 | 86 | 9 | 5 | LFS | - | - | 0.04 |

WARDLOW SERIES

Location: NW1, Twp 17, Rge 11, W4
Classification: Brown Solodized Solonetz
Parent material: Fluvial or lacustrine

| Horizon | Depth cm | |
|---|---|---|
| Ah | 0-5 | Brown to dark brown (10YR 4/3 m), grayish brown (10YR 5/2 d); silt loam; weak, fine granular; very friable; abundant, very fine, random roots; abrupt, smooth boundary; 4-8 cm thick; slightly acid. |
| Ae | 5-10 | Brown to dark brown (10YR 4/3 m), light brownish gray (10YR 6/2 d); silt loam; weak, fine platy; friable; abundant, very fine, random roots; abrupt, smooth boundary; 4-6 cm thick; neutral. |
| Bnt | 10-30 | Brown to dark brown (10YR 4/3 m, d), dark brown (10YR 3/3 ped); silty clay loam; compound, moderate, medium columnar, and moderate, medium, subangular blocky; very firm; abundant, very fine, vertical, exped roots; many, moderately thick, clay films; clear, wavy boundary; 15-20 cm thick; neutral. |
| Ck | 30-41 | Brown (10YR 5/3 m), light brownish gray (10YR 6/2 d); silty clay loam to silty clay; moderate, medium to coarse, subangular blocky; firm; plentiful, very fine, vertical roots; moderate effervescence; gradual, wavy boundary; 8-12 cm thick; moderately alkaline. |
| Csk1 | 41-107 | Light brownish gray (10YR 6/2 m), light gray (10YR 7/2 d); silty clay loam; massive; firm; few, very fine, vertical roots; strong effervescence; abrupt, wavy boundary; 60-70 cm thick; moderately alkaline. |
| Csk2 | 107-163 | Pale brown (10YR 6/3 m), very pale brown (10YR 7/3 d); silty clay loam; massive; firm; very few, very fine, vertical roots; very weak effervescence; abrupt, wavy boundary; 50-60 cm thick; mildly alkaline. |
| Csk3 | 163-274 | Pale brown (10YR 6/3 m), very pale brown (10YR 7/3 d); silty clay loam; massive; firm; very weak effervescence; mildly alkaline. |

| Hor. | Depth cm | pH ($H_2O$) | % N | % O.C. | Exchangeable cations meq/100 g Na | K | Ca | Mg | T.E.C. meq/100 g | Ca/Na ratio | % $CaCO_3$ equiv. | Particle size % sand | % silt | % clay | Text. | E.C. mS/cm | S.A.R. | Est. avail. moist. cm/cm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ah | 0-5 | 6.5 | 0.2 | 2.4 | 0.2 | 1.4 | 5.6 | 2.1 | 15.8 | 25 | - | 18 | 63 | 19 | SiL | - | - | 0.24 |
| Ae | 5-10 | 6.6 | 0.1 | 1.5 | 0.3 | 0.9 | 4.5 | 2.0 | 14.4 | 17 | - | 18 | 65 | 17 | SiL | - | - | 0.17 |
| Bnt | 10-30 | 6.9 | 0.1 | 1.1 | 1.3 | 0.9 | 10.5 | 6.8 | 23.9 | 8 | - | 11 | 52 | 37 | SiCL | - | - | 0.16 |
| | | | | | Soluble salts meq/L | | | | | | | | | | | | | |
| Ck | 30-41 | 8.2 | - | - | 4.9 | 0.1 | 2.0 | 0.3 | - | - | 2.5 | 4 | 56 | 40 | SiCL | 2 | 5 | - |
| Csk1 | 41-107 | 8.0 | - | - | 17.4 | 0.3 | 23.1 | 6.4 | - | - | 3.5 | 2 | 60 | 38 | SiCL | 8 | 5 | - |
| Csk2 | 107-163 | 7.5 | - | - | 22.6 | 0.2 | 20.6 | 11.6 | - | - | 0.9 | 1 | 61 | 38 | SiCL | 11 | 6 | - |
| Csk3 | 163-274 | 7.4 | - | - | 39.1 | 0.4 | 22.1 | 12.5 | - | - | 1.0 | 10 | 57 | 33 | SiCL | 12 | 9 | - |

## YARNLEY SERIES

Location: NE7, Twp 22, Rge 14, W4
Classification: Brown Solodized Solonetz
Parent material: Sandy fluvial or eolian

| Horizon | Depth cm | |
|---|---|---|
| Ah | 0-25 | Very dark grayish brown (10YR 3/2 m); loamy sand; single grain; very friable; abundant, coarse to micro, vertical roots; clear, smooth boundary; 23-27 cm thick; moderately alkaline. |
| Ae | 25-36 | Dark grayish brown (10YR 4/2 m); sand; single grain; loose; few, medium to micro, vertical roots; abrupt, irregular boundary; 7-26 cm thick; strongly alkaline. |
| Bnk1 | 36-60 | Dark grayish brown to brown (10YR 4/2.5 m); loamy sand; compound, weak, very coarse columnar, and single grain; friable; few, fine and very fine, vertical roots; very weak effervescence; gradual, smooth boundary; 10-28 cm thick; strongly alkaline. |
| Bnk2 | 60-70 | Dark brown (10YR 3/3 m); loamy sand; compound, very weak, medium, subangular blocky, and single grain; friable; few, fine and very fine, vertical roots; weak effervescence; clear, smooth boundary; 7-12 cm thick; strongly alkaline. |
| Ckcj | 70-98 | Yellowish brown (10YR 5/4 m); loamy sand; single grain; very friable; continuous, weak cementation; very few, very fine, vertical roots; very weak effervescence; diffuse, irregular boundary; 24-32 cm thick; strongly alkaline. |
| Ckgcj | 98-135+ | Light olive brown (2.5Y 5/4 m crushed), grayish brown to light brownish gray (2.5Y 5.5/2 matrix); loamy sand; single grain; very friable; continuous, weak cementation; many, coarse, prominent, light olive brown (2.5Y 5/5) mottles; very weak effervescence; strongly alkaline. |

| Hor. | Depth cm | pH ($H_2O$) | % N | % O.C. | Exchangeable cations meq/100 g Na | K | Ca | Mg | T.E.C. meq/100 g | Ca/Na ratio | % $CaCO_3$ equiv. | Particle size % sand | % silt | % clay | Text. | E.C. mS/cm | S.A.R. | Est. avail. moist. cm/cm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ah | 0-25 | 7.5 | 0.1 | 0.6 | 0.5 | 0.6 | 4.4 | 1.2 | 6.3 | 5 | - | 87 | 11 | 2 | FS | <1 | 1 | 0.03 |
| | | | | | Soluble salts meq/L | | | | | | | | | | | | | |
| Ae | 25-36 | 8.8 | tr | 0.2 | 5.8 | 0.1 | 0.8 | 0.4 | 3.4 | - | - | 88 | 12 | - | FS | 1 | 1 | 0.01 |
| Bnk1 | 36-60 | 9.5 | tr | 0.1 | 19.6 | 0.1 | 1.7 | 0.7 | 6.3 | - | 0.5 | 86 | 11 | 3 | FS | 2 | 18 | 0.05 |
| Bnk2 | 60-70 | 9.4 | - | 0.2 | 27.0 | 0.1 | 1.9 | 0.9 | 7.4 | - | 1.7 | 86 | 9 | 5 | LFS | 2 | 23 | 0.08 |
| Ckcj | 70-98 | 9.2 | - | - | 28.7 | 0.1 | 1.4 | 0.5 | 7.4 | - | 1.3 | 85 | 10 | 5 | LFS | 2 | 29 | 0.08 |
| Ckgcj | 98-135 | 8.8 | - | - | 58.3 | 0.1 | 0.5 | 0.4 | 7.4 | - | 1.6 | 86 | 9 | 5 | LFS | 1 | 88 | 0.07 |

## APPENDIX C. GLOSSARY OF TERMS

acid soil - A soil having a pH of less than 7.0.

aggregate - A group of soil particles cohering so as to behave mechanically as a unit.

alkaline soil - Any soil that has a pH greater than 7.0.

alluvial deposit (alluvium) - Material deposited by moving water.

Atterberg limits - Various moisture contents of a soil at whichit changes from one major physical state to another. The Atterberg limits which are most useful for engineering purposes are liquid limit and plastic limit. The liquid limit is the moisture content at which a soil passes from a plastic to a liquid state. The plastic limit is the moisture content at which a soil changes from a semisolid to a plastic state. Plasticity index (P.I.) is defined as the numerical difference between liquid limit and plastic limit.

badland - A land type generally devoid of vegetation and broken by an intricate maze of narrow ravines, sharp crests, and pinnacles resulting from serious erosion of soft geologic materials. Most common in arid or semiarid regions.

bedrock - The solid rock underlying soils and the regolith or exposed at the surface.

bulk density, soil - The mass of dry soil per unit bulk volume.

calcareous soil - Soil containing sufficient calcium carbonate (often with magnesium carbonate) to effervesce visibly when treated with cold 0.1 N hydrochloric acid.

capability class - (soil) - The class indicates the general suitability of the soils for agricultural use. It is a grouping of subclasses that have the same relative degree of limitation or hazard. The limitation or hazard becomes progressively greater from class 1 to class 7.

capability subclass - (soil) - This is a grouping of soils with similar kinds of limitations and hazards. It provides information on the kind of conservation problem or limitation. The class and subclass together provide the map user with information about the degree and kind of limitation for broad land use planning and for the assessment of conservation needs.

carbon-nitrogen ratio - The ratio of the weight of organic carbon to the weight of total nitrogen in a soil or in organic material. It is obtained by dividing the percentage of organic carbon (C) by the percentage of total nitrogen (N).

cation - An ion carrying a positive charge of electricity; the common soil cations are calcium, magnesium, sodium, potassium, and hydrogen.

cation exchange capacity (C.E.C.) - A measure of the total amount of exchangeable cations that can be held by the soil; it is expressed in terms of milliequivalents per 100 g of soil (meq/100 g).

chroma - The relative purity, strength, or saturation of a color; directly related to the dominance of the determining wavelength of light and inversely related to grayness; one of the three variables of color.

classification, soil - The systematic arrangement of soils into categories and classes on the basis of their characteristics. Broad groupings are made on the basis of general characteristics and subdivisions on the basis of more detailed differences in specific properties.

clay - (as a particle-size term) - A size fraction with an equivalent diameter of <0.002 mm.

clod - A compact, coherent mass of soil produced by digging or plowing.

coarse fragments - Rock or mineral particles >2.0 mm in diameter.

coarse texture - The texture exhibited by sands, loamy sands, and sandy loams except very fine sandy loam. A term applied to a soil containing large quantities of these textural classes.

concretion - A local concentration of a chemical compound, such as calcium carbonate or iron oxide, in the form of a grain or nodule of varying size, shape, hardness, and color.

consistency - (i) The resistance of a material to deformation or rupture. (ii) The degree of cohesion or adhesion of the soil mass.

control section - The vertical section upon which soil classification is based.

deposit - Material left in a new position by a natural transporting agent such as water, wind, ice, or gravity, or by the activity of man.

droughty soil - Sandy or very rapidly drained soil.

dryland farming - The practice of crop production in low-rainfall areas without irrigation.

dunes - Wind-built ridges and hills of sand formed in the same manner as snowdrifts. They are started by some obstruction such as a bush, boulder, fence, or other obstacle which causes an eddy, or otherwise thwarts the sand-laden wind. Once begun, the dunes themselves offer further resistance and they grow to form various shapes.

eluviation - The removal of soil material in suspension or in solution from a layer or layers of soil.

engineering tests - Laboratory tests made to determine the physical properties of soils that affect their uses for various types of engineering construction.

eolian deposit - Material deposited by wind, including both loess and dune sand.

erosion - The wearing away of the land surface by running water, wind, ice, or other geological agents, including such processes as gravitational creep.

exchange capacity - The total ionic charge of the adsorption complex active in the adsorption of ions.

fertility, soil - The status of a soil with respect to the amount and availability to plants of elements necessary for plant growth.

fertilizer - Any organic or inorganic material of natural or synthetic origin which is added to a soil to supply certain elements essential to the growth of plants.

fine textured - Consisting of or containing large quantities of the fine fractions, particularly of silt and clay.

floodplain - The land bordering a stream, built up of sediments from overflow of the stream and subject to inundation when the stream is at flood stage.

fluvial deposits - All sediments, past and present, deposited by flowing water, including glaciofluvial deposits.

friable - A consistency term pertaining to the ease of crumbling of soils.

frost-free period - Period of the year between the last frost of spring and first frost of fall.

glacial drift - All rock material transported by glacier ice or glacial meltwater, or rafted by icebergs. This term includes till, stratified drift, and scattered rock fragments.

glaciofluvial deposits - Material moved by glaciers and subsequently sorted and deposited by streams flowing from the melting ice. The deposits are stratified and may occur in the form of outwash plains, deltas, kames, eskers, and kame terraces.

gravelly - Containing appreciable or significant amounts of gravel.

ground moraine - Generally an unsorted mixture of rocks, boulders, sand, silt, and clay deposited by glacial ice. The predominant material is till, though stratified drift is present in places. The till is thought to have accumulated largely by lodgment beneath the ice but partly also by being let down from the upper surface of the ice through the ablation process. Ground moraine is most commonly in the form of undulating plains with gently sloping swells, sags, and enclosed depressions.

groundwater - That portion of the total precipitation which at any particular time is either passing through or standing in the soil and the underlying strata and is free to move under the influence of gravity.

horizon - A layer in the soil profile approximately parallel to the land surface with more or less well-defined characteristics that have been produced through the operation of soil-forming processes. Soil horizons may be organic or mineral.

hue - One of the three variables of color. It is caused by light of certain wavelengths and changes with the wavelength.

hummocky - Abounding in rounded or conical knolls or mounds and depressions, generally of equidimensional shape and not ridge-like.

illuviation - The process of deposition of soil material removed from one horizon to another in the soil, usually from an upper to a lower horizon in the soil profile. Illuviated substances include silicate clay, iron and aluminum hydrous oxides, and organic matter.

immature soil - A soil with indistinct or only slightly developed horizons.

impeded drainage - A condition that hinders the movement of water through soils under the influence of gravity.

impervious - Resistant to penetration by fluids or by roots.

indicator plants - Plants characteristic of specific soil or site conditions.

infiltration - The downward entry of water into the soil.

intergrade - A soil that possesses moderately well developed distinguishing characteristics of two or more genetically related taxa.

irrigation - The artificial application of water to the soil for the benefit of growing crops.

lacustrine deposit - Material deposited in lake water and later exposed either by lowering of the water level or by uplift of the land. These sediments range in texture from sands to clays.

landscape - All the natural features such as fields, hills, forests, water, etc., that distinguish one part of the earth's surface from another part. Usually that portion of land or territory which the eye can comprehend in a single view, including all its natural characteristics.

leaching - The removal of materials in solution from the soil.

lime concretion - An aggregate of precipitated calcium carbonate, or of other material cemented by precipitated calcium carbonate.

liquid limit - (upper plastic limit) - (i) The water content corresponding to an arbitrary limit between the liquid and plastic states of consistency of a soil. (ii) The water content at which a pat of soil, cut by a groove of standard dimensions, will flow together for a distance of 12 mm under the impact of 25 blows in a standard liquid limit apparatus.

loose - A soil consistency term.

matrix, soil - The soil material that encloses other soil features, e.g., concretions embedded in a fine-grained matrix.

mature soil - A soil with well developed soil horizons produced by the natural processes of soil formation.

medium texture - Intermediate between fine texture and coarse texture of soils. It includes the following textural classes: very fine sandy loam, loam, silt loam, and silt.

microrelief - Small-scale, local differences in topography, including mounds, swales, or pits that are only about 1 m in diameter and have elevation differences of up to 2 m.

moderately coarse texture - Consisting predominantly of coarse particles. In soil textural classification, it includes all the sandy loams except very fine sandy loam.

moderately fine texture - Consisting predominantly of intermediate-sized particles. In soil textural classification, it includes clay loam, sandy clay loam, and silty clay loam.

mottles - Spots or blotches of different color or shades of color interspersed with the dominant color.

Munsell color system - A color designation system that specifies the relative degree of the three simple variables of color; hue, value, and chroma. For example: 10YR 6/4 is a color (or soil) with a hue of 10YR, value of 6, and chroma of 4. These notations can be translated into several different systems of color names as desired. See chroma, hue, and value.

neutral soil - A soil in which the surface layer, at least to normal plow depth, is neither acid nor alkaline in reaction.

organic matter - The decomposition residues of plant material derived from: (a) plant materials deposited on the surface of the soil; and (b) roots that decay beneath the surface of the soil.

outwash - Sediments "washed out" by flowing water beyond the glacier and laid down in thin foreset beds as stratified drift. Particle size may range from boulders to silt.

parent material - The unconsolidated and more or less chemically weathered mineral or organic matter from which the solum of a soil is developed by pedogenic processes.

particle size - The effective diameter of a particle measured by sedimentation, sieving, or micrometric methods.

ped - A unit of soil structure such as a prism, block, or granule, formed by natural processes (in contrast to a clod, which is formed artificially).

pedology - Those aspects of soil science involving the constitution, distribution, genesis, and classification of soils.

percolation, soil water - The downward movement of water through soil. Especially, the downward flow of water in saturated or nearly saturated soil at hydraulic gradients of the order of 1.0 or less.

pH, soil - The negative logarithm of the hydrogen-ion activity of a soil. The degree of acidity (or alkalinity) of a soil as determined by means of a glass, quinhydrone, or other suitable electrode or indicator at a specified moisture content or soil-water ratio, and expressed in terms of the pH scale.

phase, soil - A subdivision of a soil type or other unit of classification having characteristics that affect the use and management of the soil but which do not vary sufficiently to differentiate it as a separate type. A variation in a property or characteristic such as degree of slope, degree of erosion, content of stones, etc.

plastic limit - (i) The water content corresponding to an arbitrary limit between the plastic and the semisolid states of consistency of a soil. (ii) Water content at which a soil will just begin to crumble when rolled into a thread approximately 3 mm in diameter.

plasticity index - The numerical difference between the liquid and the plastic limit or, synonymously, between the lower plastic limit and the upper plastic limit.

platy - Consisting of soil aggregates that are developed predominately along the horizontal axes; laminated; flaky.

profile, soil - A vertical section of the soil through all its horizons and extending into the parent material.

reaction, soil - The degree of acidity or alkalinity of a soil, usually expressed as a pH value.

residual material - Unconsolidated and partly weathered mineral materials accumulated by disintegration of consolidated rock in place.

saline soil - A nonalkali soil containing soluble salts in such quantities that they interfere with the growth of most crop plants. The conductivity of the saturation extract is greater than 4 mmhos/cm, the exchangeable-sodium percentage is less than 15, and the pH is usually less than 8.5.

salinization - The process of accumulation of salts in soil.

sand - A soil particle between 0.05 and 2.0 mm in diameter.

series, soil - The second category (II) in the Canadian classification system. The series is the basic unit of soil classification and consists of soils that are essentially alike in all major profile characteristics except the texture of the surface.

silt - A soil separate consisting of particles between 0.05 and 0.002 mm in equivalent diameter.

soil - The unconsolidated mineral material on the immediate surface of the earth that serves as a natural medium for the growth of land plants.

soil complex - A mapping unit used in detailed and reconnaissance soil surveys where two or more defined soil units are so intimately intermixed geographically that it is impractical, because of the scale used, to separate them.

soil genesis - The mode of origin of the soil with special reference to the processes or soil-forming factors resonsible for the development of the solum, or true soil, from the unconsolidated parent material.

soil map - A map showing the distribution of soil types or other soil mapping units in relation to the prominent physical and cultural features of the earth's surface.

soil moisture - Water contained in the soil.

soil structure - The combination or arrangement of primary soil particles into secondary particles, units, or peds. These secondary units may be, but usually are not, arranged in the profile in such a manner as to give a distinctive characteristic pattern. The secondary units are characterized and classified on the basis of size, shape, and degree of distinctness into classes, types, and grades, respectively.

soil survey - The systematic examination, description, classification, and mapping of soils in an area. Soil surveys are classified according to the kind and intensity of field examination.

soil variant - A soil whose properties are believed to be sufficiently different from other known soils to justify a new series name but comprising such a limited geographic area that creation of a new series is not justified.

solum - (plural sola) - The upper horizons of a soil in which the parent material has been modified and within which most plant roots are confined. It consists usually of A and B horizons.

terrace - A level, usually narrow, plain bordering a river, lake, or the sea. Rivers sometimes are bordered by a number of terraces at different levels. There are also man-made terraces.

till - Unstratified glacial drift deposited directly by the ice and consisting of clay, sand, gravel, and boulders intermingled in any proportion.

toposequence - A sequence of related soils that differ, one from the other, primarily because of topography as a soil-formation factor.

value, color - The relative lightness or intensity of color and approximately a function of the square root of the total amount of light. One of the three variables of color.

veneer - Unconsolidated materials too thin to mask the minor surface irregularities of the underlying unit. A veneer ranges between 10 cm and 1 m in thickness and possesses no form typical of the materials' genesis.

weathering - The physical and chemical disintegration, alteration, and decomposition of rocks and minerals at or near the earth's surface by atmospheric agents.

MAPS NOT

FILMED

CARTES

OMISES